Undergraduate Research Symposium May 18, 2012 Mary Gates Hall

Online Proceedings

POSTER SESSION 3

Balcony, Easel 116

4:00 PM to 5:30 PM

Optimization of Traumatic Brain Injury Imaging via Ultrasound Elastography

Zinnia Siyun Xu, Senior, Bioengineering
Mary Gates Scholar
Mentor: Pierre Mourad, Neurological Surgery

Many soldiers acquire traumatic brain injuries (TBI), such as edema, hemorrhage, and traumatic axonal injury, from improvised explosive devices. Currently there are no adequate brain-imaging devices for use near the battle field. Patients with TBI may require a complete hemicraniectomy to examine the extent and location of the injury. This presents a great need for field-deployable imaging devices optimized for brain imaging with the spatial resolution of CT scans. Previous work has shown that intraoperative ultrasound, ultrasound used during surgery, can create images of brain-based tissue stiffness. For this project, rats have been given TBI using controlled cortical impact methods and their brains have been imaged using shear wave imaging to quantify the stiffness of brain tissue. The ultrasound images have shown patterns of brain stiffness that exhibit the extent and location of TBI. After the brain tissue stiffness for TBI was quantified using shear wave ultrasound, the data was used to optimize ultrasound machines for imaging moderate TBI. The Verasonics ultrasound device in the lab was optimized to image brain tissue by tracking the shear wave, generated by the transducer, as it propagates through brain tissue and correlating propagation speed with stiffness values. The images obtained from the ultrasound device were compared against histology. The success of this project would ultimately lead to increased quality of care for soldiers with TBI near the battlefield.

POSTER SESSION 3

Balcony, Easel 117

4:00 PM to 5:30 PM

Ultrasound Elastography is Sensitive to Changes in Brain after Stroke

Anning Yao, Senior, Bioengineering
Washington Research Foundation Fellow
Mentor: Pierre Mourad, Neurological Surgery

Stroke is the degeneration of brain tissue caused by blockage of blood flow to the brain. It is one of the leading causes of adult disability and death worldwide. We used ultrasound elastography, a technique that measures local tissue deformation from ultrasound-induced shear wave propagation, to measure shear modulus, the ratio of shear stress to the shear strain, of brain tissue after ischemic infarction, loss of brain function due to low brain blood supply, to determine changes in individual hemisphere due to that injury. We imaged live mice that were 3 hours (hyperacute), 24 hours (acute) and 72 hours (subacute) after surgical occlusion of the middle cerebral artery, and measured the shear modulus of ipsilateral and contralateral brain hemispheres compared to corresponding values of control mice. The mice with hyperacute stroke showed statistically significant increase in shear modulus in both hemispheres compared with control animals. The mice with acute stroke showed a significantly decreased shear modulus in ipsilateral hemisphere and a significantly increased shear modulus in contralateral hemispheres compared to control mice. The mice with subacute stroke showed no significant difference in shear modulus compared to control mice. Significant differences were shown between ipsilateral and contralateral shear modulus values measured 24 hours and 72 hours after infarction. We hypothesize that the shear modulus differences among hyperacute, acute, and subacute stroke mice reflect the initial development of edema and reduction of cerebral blood flow in the ipsilateral hemisphere, and the initial reduction of blood flow then later development of edema in the contralateral hemisphere. Thus, ultrasound elastography may be a sensitive method to detect subtle changes in brain elasticity post stroke. Future work will include an attempt to remove the imaging artifact through the design of a new elastic imaging machine. This research will be a key step toward exploring the ultrasound parameters for imaging stroke, which will ultimately contribute to the development of a better imaging tool for potential stroke patients.

POSTER SESSION 3

Balcony, Easel 115

4:00 PM to 5:30 PM

Ultrasonic Neuromodulation: Optimizing Neural Stimulation

Edin Mehic, Senior, Bioengineering
Mentor: Pierre Mourad, Neurological Surgery

Ultrasonic neuromodulation is the process of stimulating different neural pathways in the brain through the use of transcranially delivered ultrasound in order to induce clinically relevant emotional, cognitive, physical or behavioral reactions. My research goal is to find out if it is possible to add anatomical specificity to neuromodulation through the use of modulated focused ultrasound (mFU), where 'modulated' refers to adding complex temporal structure to the waveform to optimize neuromodulation. Since mFU has a small focus relative to the brain, the acoustic power from the ultrasound can be moved within the brain; previous experiments have used unfocused ultrasound which sends ultrasound through the entire brain. We hypothesize that we can map varying physical reactions through stimulation of different parts of the brain, with our initial emphasis on the motor cortex because stimulation there produces readily observable results. With lightly anesthetized mice as our subjects, and always delivering ultrasound through the skin and skull, we began neuromodulation with unfocused transducers to transmit our ultrasound. This critical step was done to determine the optimal intensity, waveform shape and carrier frequency of ultrasound that created a robust observable effect. Next we translated these ultrasound parameters to our mFU transducer. The current stage of the process includes moving through different parts of each hemisphere and recording the associated motor response such as leg movements and tail flicks. We have already seen a change in activity between activating the quadrant of the brain containing motor cortex relative to the opposite quadrant. Going forward, we intend to see if we could produce varied motor movements as we change the point of stimulation within the brain hemisphere containing the motor cortex, along with changes in applied intensity, and duration of stimulation. Clinical implications for neuromodulation research include retraining brain function after injury.

POSTER SESSION 3

Balcony, Easel 105

4:00 PM to 5:30 PM

Effects of *In utero* Exposure to Standard Diagnostic Ultrasound on Autistic-Like Behaviors in Mice

Abigail Marie (Abbi) Mc Clintic, Senior, Environmental Health, French

Mary Gates Scholar, NASA Space Grant Scholar

Chelsea Ray (Chelsea) Brossard, Junior, Chemistry

NASA Space Grant Scholar

Mentor: Pierre Mourad, Neurological Surgery

This project will investigate the hypothesis that in utero exposure to clinically relevant doses of diagnostic ultrasound increases the risk for the manifestation of symptoms of autism. It is hypothesized that autism is caused by a triple hit of risk factors: a genetic susceptibility, a developmental time window of vulnerability, and an environmental factor. Diagnostic ultrasound is a candidate environmental factor within this "Triple Hit Hypothesis" for autism. To take the first steps toward testing our hypothesis, we propose to assay for ultrasound-associated changes in behavior and neuroanatomy of three mouse strains that have been well characterized in terms of social behavior. One strain is known for normal social behavior and the other two are known to exhibit autistic-like behaviors. Specifically, standard diagnostic ultrasound will be applied to mice at a key developmental time point during pregnancy to half of a group of mothers, and the other half will undergo the same procedure, but the ultrasound will not be turned on (sham application). At three weeks of age, the social, repetitive, and other relevant behaviors of the pups will be assayed using a battery of tests that includes a social approach test, a juvenile play test, open field observation, and several other methods. We will then analyze the data for significant differences in magnitude or occurrence of these behaviors within the three strains of mice based on their ultrasound exposure group. If the magnitude and/or occurrence of these behaviors are greater in the ultrasound-exposed group compared to the sham group in at least one of these strains, then our hypothesis will be supported and further experiments will be critical.