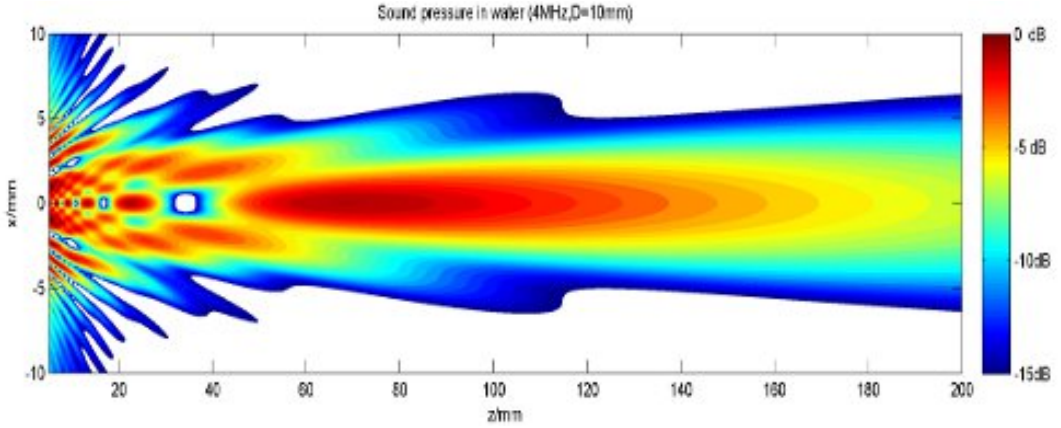
HossackLab



Ultrasound is applied to the diagnosis of many different disease conditions: heart conditions, vascular health (e.g. to visualize plaque that may be associated with Stroke), liver and kidney diseases and a variety of high resolution shallow imaging applications – e.g. breast imaging for cancer diagnosis and musculoskeletal areas – wrists, shoulder muscles, etc. Our work encompasses: ultrasound-based molecular imaging, transducer design, microbubble-based drug delivery, therapeutic ultrasound and ultrasound signal/image processing and quantification.

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"Developing new technologies to improve the clinical value of ultrasound in diagnosis and therapy."

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Molecular Imaging

We have introduced a modified real-time approach for selectively imaging and guiding microbubbles in the context of identifying carotid arteries susceptible to stroke. A Singular Value Decomposition method is used to separate signals associated with bound microbubbles (i.e. the signature of a molecular marker (e.g. VCAM-1) being present) from unbound microbubbles that contain no information about the presence of molecular markers.

Therapeutic Applications of Microbubbles

In the past decade, the therapeutic applications of microbubbles have emerged, primarily motivated by the need of a suitable drug/gene delivery agent. Our efforts address clinical needs in the field of atherosclerosis – progressive narrowing of arteries (e.g. coronary and peripheral). Current methods use a drug eluting stent to deliver a fixed dose of a fixed drug to a limited region of a vessel wall. The drug serves to prevent in-stent restenosis – re-narrowing of the vessel following an initial procedure to treat the atherosclerosis. In our method, we use a modified intravascular ultrasound catheter that delivers drug-loaded microbubbles. We can then use the catheter to image the microbubbles. Most recently, we have been developing new microfluidics-based approaches to form a stream of precisely controlled microbubbles that are optimized for drug delivery. In particular, we have observed that by combining a stream of large, yet unstable, microbubbles with a clinically approved "clot busting" drug (tPA), that we can achieve an eight fold increase in the rate of clot dissolution. Thus, we believe we can have long-term impact in the related fields of ischemic stroke, deep venous thrombosis (DVT) and pulmonary embolism (PE).

Mouse Heart Imaging

The mouse is the preferred species for cardiovascular research of both the genetic mechanisms that underpin cardiovascular disease and the evolution of anatomic and physiological responses to disease and therapy. One current method for non-invasive mouse imaging (MRI) has excellent image qualities but it has a number of significant drawbacks. We are researching an ultrasound method that provides accurate, low-cost, fast, and non-invasive quantification of cardiac left ventricular (LV) function in small animals. The spatial resolution is sufficient to enable calculation of important anatomic and physiologic parameters (chamber volumes, ejection fraction, etc.) Further, we take advantage of the superior temporal resolution to enable assessment of mouse LV perfusion using analysis of the time evolution of myocardial video intensity following a bolus contrast agent injection.

Ultrasound for protection from Ischemia Reperfusion Injury in Acute Kidney Injury

It has recently been discovered, verified in murine and swine models, that controlled ultrasound exposure can provide protection from IRI in the case of AKI. Significantly, the same technique may have applications beyond AKI – for example for the post myocardial infarction ("heart attack") heart.

RECENT RESEARCH DEVELOPMENTS

- NIH grant to develop molecular imaging techniques with application to detecting risk for stroke.
- Developed catheter-based microfluidic devices with improved production rates for monodisperse (single size) microbubbles. These can be combined with "clot busting" drugs to effect an 8-fold increase in clot busting compared to standard therapy

RECENT GRANTS

- NIH-R01-Ultrasound Targeted Molecular Imaging in Large Arteries to Diagnose Stroke Risk Antiproliferative Drugs
- NIH-U18-Tailoring ultrasound technology to explore mechanisms of activation of the splenic neuroimmune axis in attenuating AKI Imaging

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