SonoKnife is a line-focused ultrasound device concept for non-invasive thermal therapy, which was motivated by the poor outcomes of advanced head and neck cancer recurrences. We hypothesized that by incorporating thermal therapy in the treatment regimen of this high risk patient population, the need for further surgery may be reduced or circumvented while enhancing the therapeutic benefits of additional conventional therapies (i.e., radiotherapy +/- chemotherapy).

The simplest SonoKnife source is a cylindrical section ultrasonic transducer, which creates a "line" focus, the length of the line being comparable to the altitude of the cylindrical section. In addition to lowering the chances of producing nonlinear and cavitation effects due to lower peak acoustic intensities (in comparison to an equivalent area point-focus radiator), we hypothesized that a line-focused device could heat/ablate a given target volume *faster*, thus reducing treatment times. Conformality to the target volume could be achieved by varying the length of the line-focus using a linear array of cylindrical sections.

In order to test feasibility and, in the long run, our hypotheses, we investigated thermal ablation (52-65°C) by SonoKnives with numerical models and experiments in phantoms, *ex-vivo* porcine liver and *in-vivo* in piglets. Line-foci were generated by cylindrical-section, single-element, ultrasound transducers whether numerically or experimentally. Numerically, simulations were performed to characterize the acoustic edge, defined as the focal volume within the 50% isobar, for basic design parameters: transducer dimensions, line-focus depth, frequency, and coupling. Experimentally, thermal ablations in gel-phantoms and *ex-vivo* samples produced lesions similar to those simulated; however, ablations in live piglets were characterized by cutaneous burns even after ice-cooling.

Essential for the clinical deployment of the SonoKnife are precise image-guidance and treatment planning. We have addressed the latter by integrating acoustic commercial software with treatment planning platforms used for radiotherapy treatment planning. Our initial efforts for both acoustic and thermal modeling in image-based anatomical space will be presented.

In summary, the modeling, in-phantom and *ex-vivo* results support the feasibility of thermal ablation with a SonoKnife. However, unless human skin is acoustically much less absorbing than the piglet's, further design modifications and studies are needed. Moreover, for a more comprehensive numerical characterization, tissue heterogeneities and nonlinear effects must be taken into account; and realistic thermal simulation studies need to be performed including scanning of the acoustic edge. Finally, the deployment of a clinical-grade system must incorporate advanced treatment planning and precise real-time image-guidance, and much work remains to be done before these are realities.

Learning Objectives:

1. Learn about the SonoKnife concept and its potential advantages relative to spherically focused HIFU transducers.
2. Appreciate how the basic design parameters affect the acoustic edge and field parameters.
3. Compare numerical, *in-aqua*, *ex-vivo* and *in-vivo* measurements and/or thermal ablation results.
4. Understand the main components and challenges for a clinical sonothermal treatment planning system.