A Patient-specific Preplanning Treatment Algorithm for Focused Ultrasound Therapy of Spinal Cord Injury

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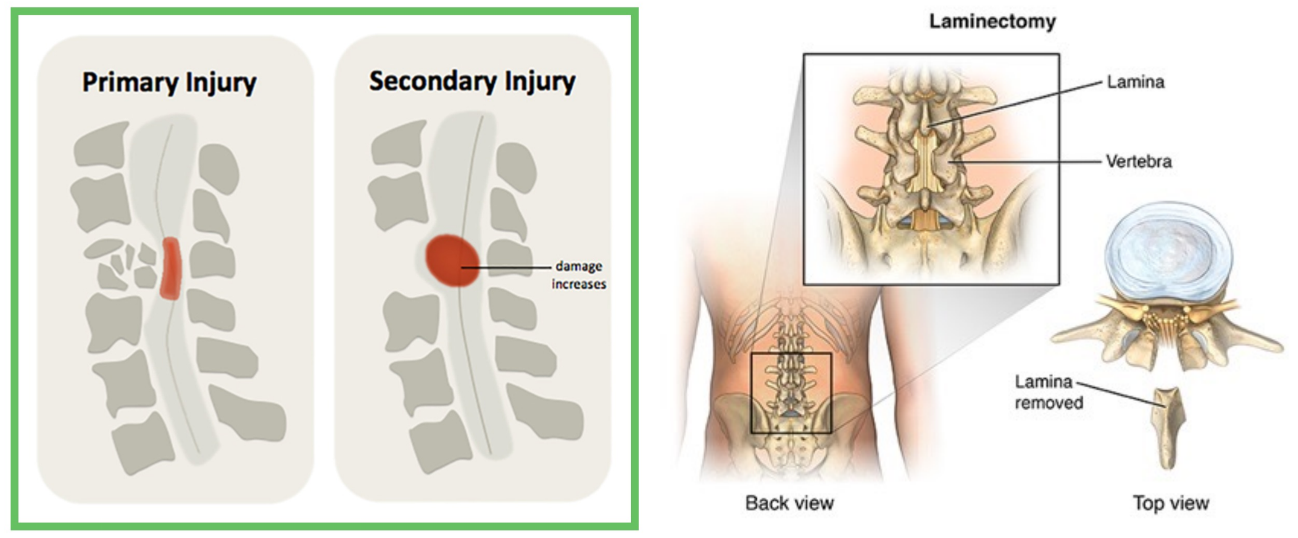
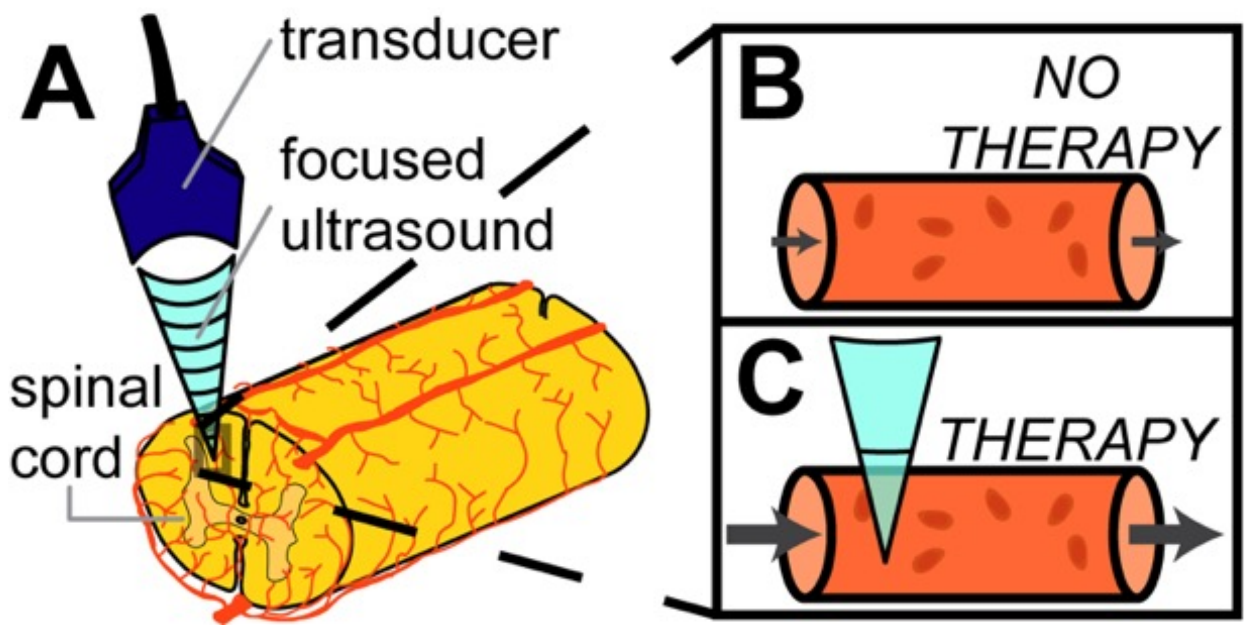
Background

Spinal cord injury (SCI) impacts 282,000 people a year in the United States [1].



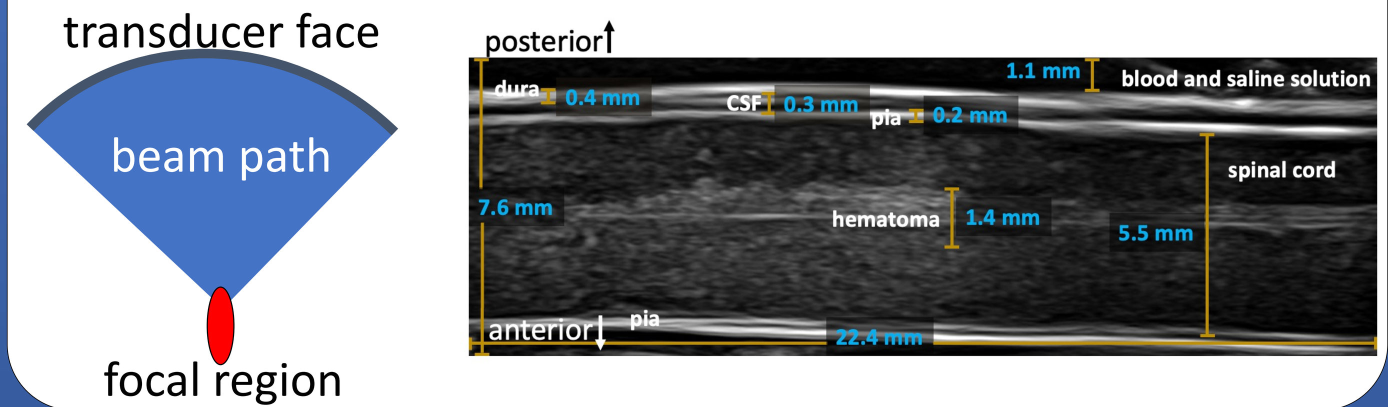
Higgens et al, Frontiers, 2017
https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/laminectomy



Focused Ultrasound can heat the cord in a controlled manner. The effectiveness of therapeutic ultrasound is determined by probe location. ***We want to minimize exposure of the focused beam on healthy tissue while simultaneously targeting the injury site.***

A few considerations:

Homogenous Medium | **Our computational grid**



Acknowledgments

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Methods

Image Acquisition:

- 23-gram weight drop in the 5th thoracic vertebrae (T5) of a female Yorkshire pig [3].
- Laminectomy performed from the 4th to 6th thoracic vertebra (T4-T6) to provide an acoustic window
- B-mode images of the sagittal cross section collected with Canon Aplio i800 ultrasound system (Canon Medical Systems, Tustin, CA) connected to an i22LH8 transducer.

k-Wave: computationally equivalent to a generalized Westervelt equation, this simulation toolbox approximated acoustic wave fields on a specified computational grid,

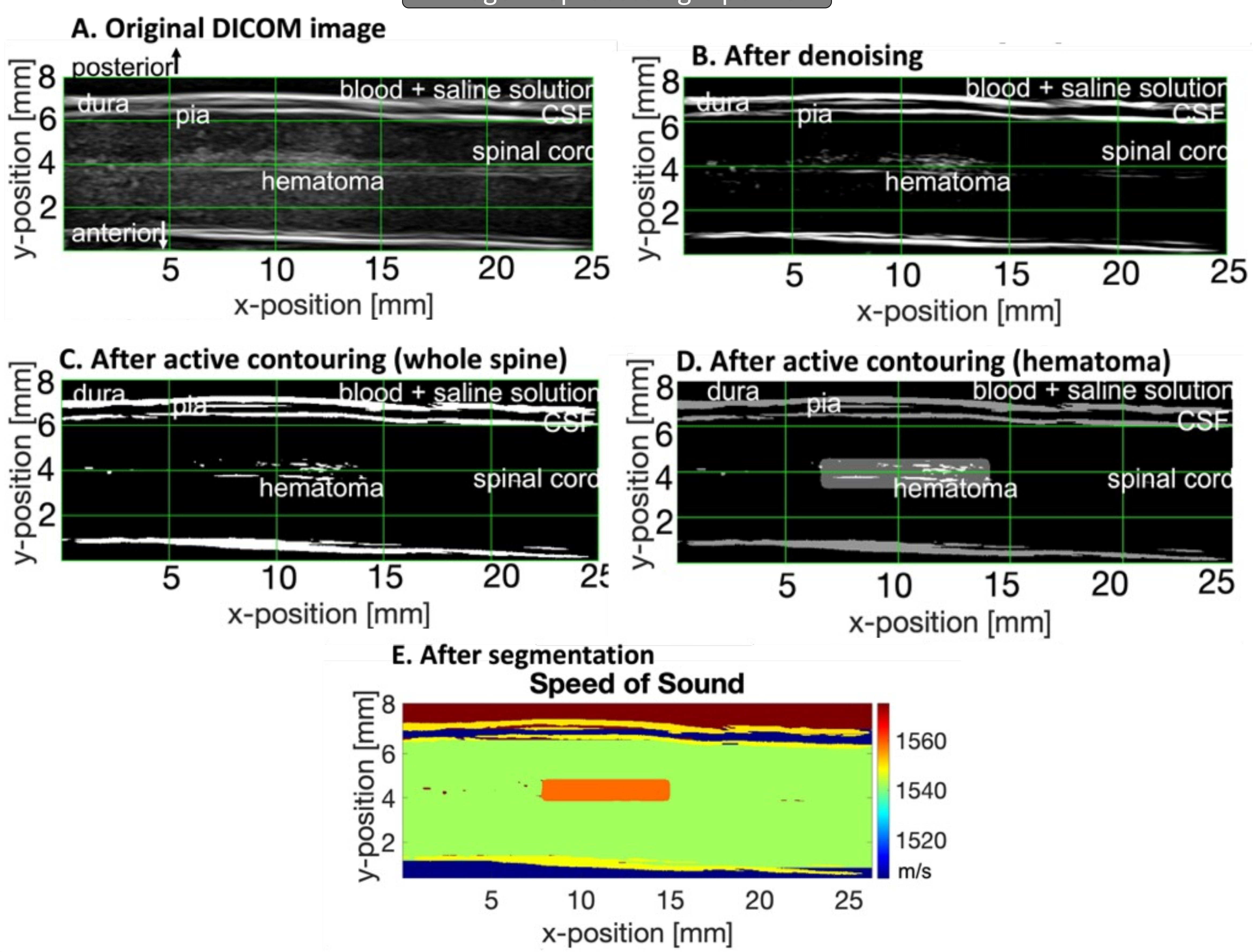
$$\frac{\partial \boldsymbol{u}}{\partial t} = -\frac{1}{\rho_0}\nabla p \qquad (1)$$

$$\frac{\partial \rho}{\partial t} = -\rho_0 \nabla \cdot \boldsymbol{u} \qquad (2)$$

$$p = c^2 \rho \qquad (3)$$

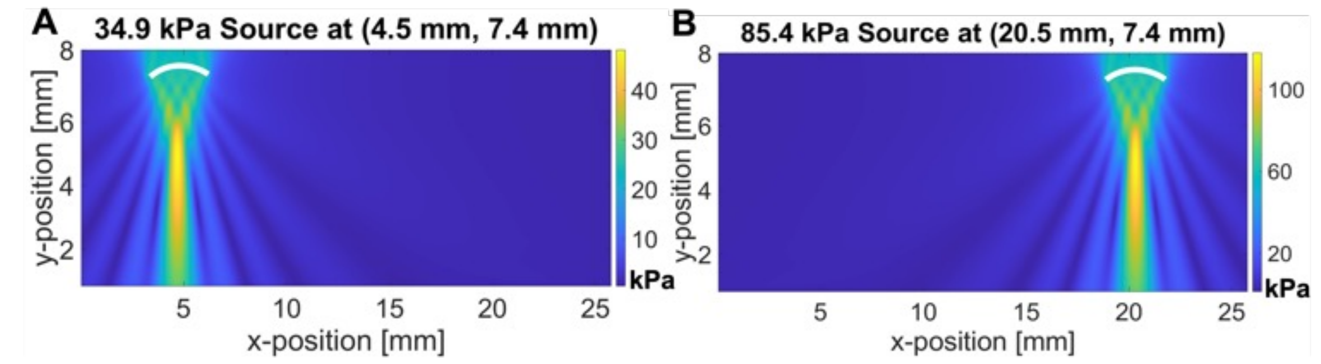
where $\boldsymbol{u}$ is the particle velocity, p is the acoustic pressure, ρ is the acoustic density, c is speed of sound through a medium, and ρ_0 is the equilibrium density [6].

Image Preprocessing Pipeline

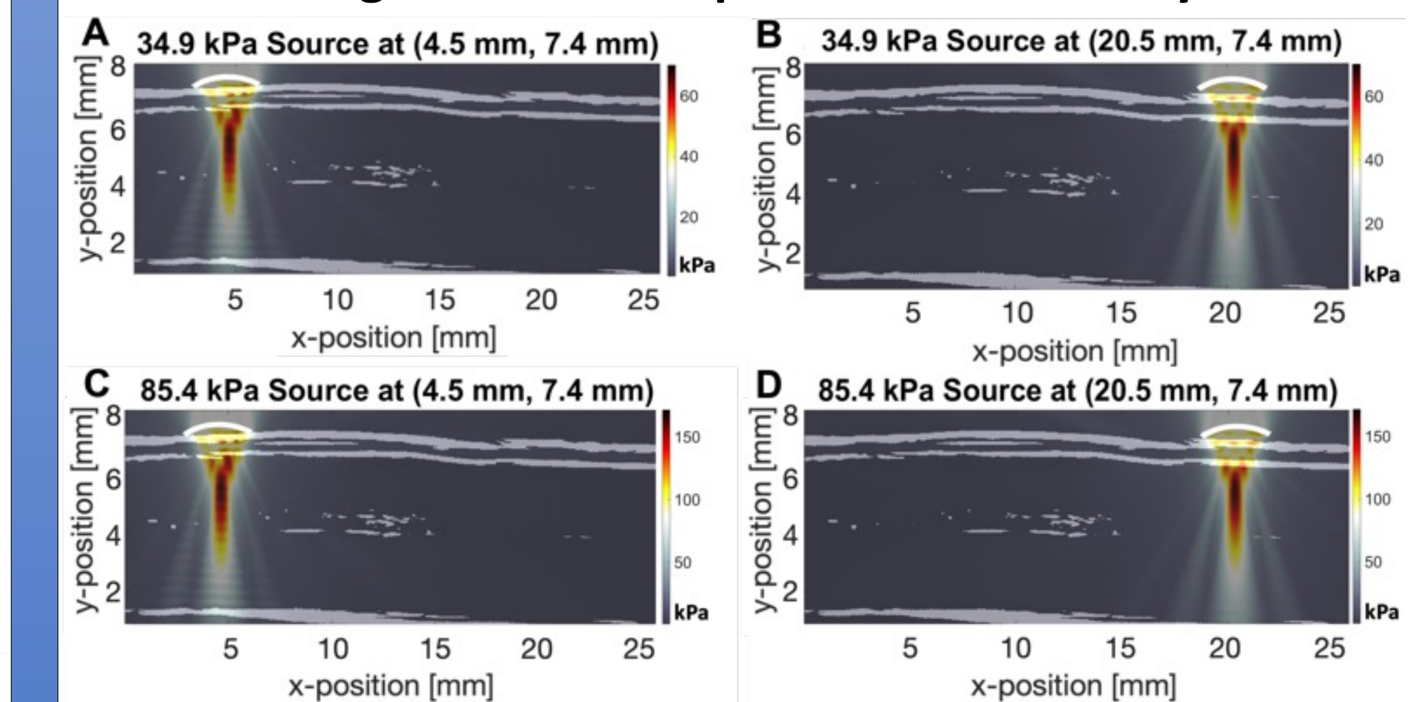


Results

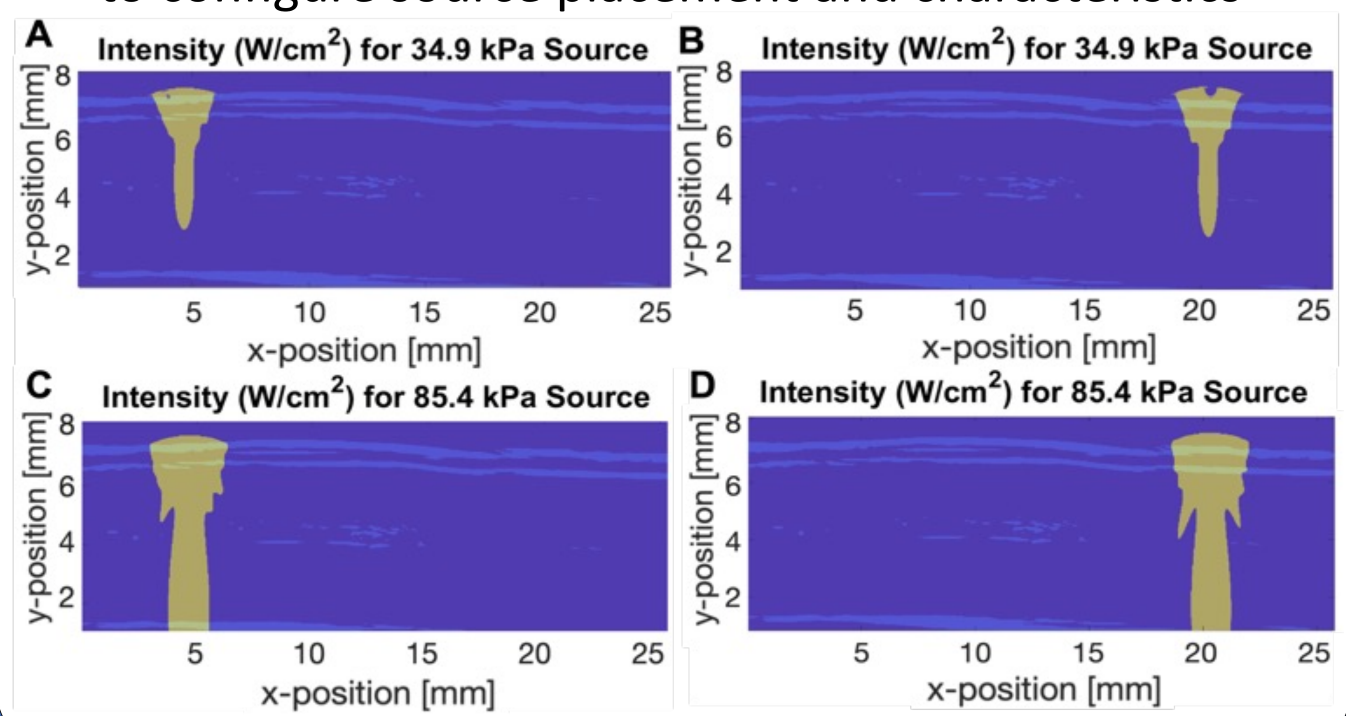
Maximum pressure (kPa) in a homogenous medium



Maximum pressure (kPa) overlaid on the ultrasound image to correlate pressure to anatomy



Intensity thresholding: Determine whether a treatment plan is suitable for patients and allows them to configure source placement and characteristics



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