A handheld tool for real-time peripheral tissue oximetry

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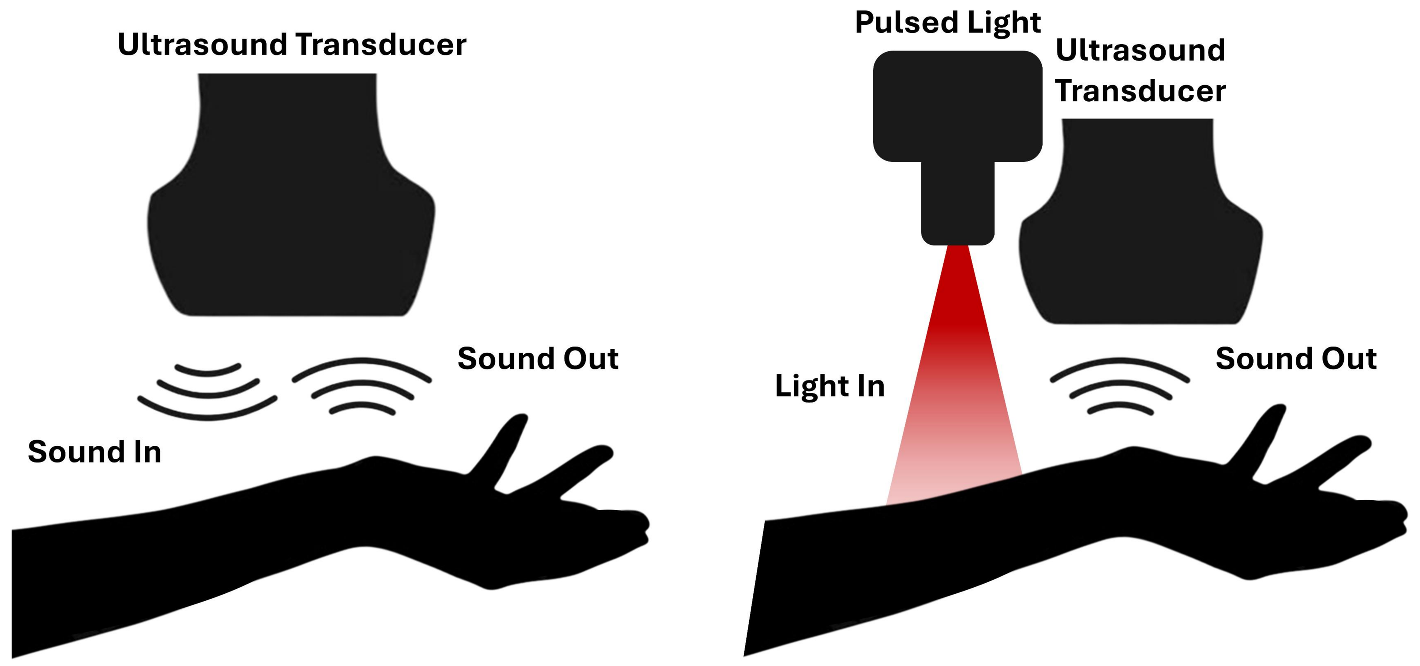
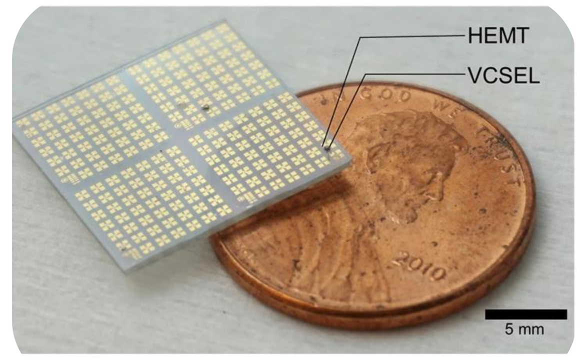
Problem and Motivation

Deep tissue pressure injuries (DTPIs) are a costly and growing healthcare challenge, often developing beneath intact skin and going undetected until significant damage has occurred. With care costs exceeding $27 billion annually and hospitals bearing full financial responsibility for any hospital-acquired cases, the burden on health systems is substantial. Current clinical practice relies almost entirely on visual inspection, which cannot assess subsurface tissue viability or oxygenation, the critical early indicators of DTPI formation. This diagnostic gap leads to delayed intervention, mislabeling of injuries, poorer patient outcomes, and higher liability for providers. Photoacoustic (PA) imaging allows deep tissue oximetry; however current systems rely on benchtop pulsed lasers that cannot be used for point of care applications. We are developing a handheld photoacoustic device to peripheral tissue oxygenation.



Methods



Quantum well semiconductor pulsed laser diode (PLD) arrays with emissions at near-infrared (NIR-II) window was used to generate PA signals. Co-registered B-mode ultrasound and PA images were acquired of in vivo rat kidney, following IACUC-approved protocols. Tissue oxygen status was varied (pre- vs. post-euthanasia hypoxia) to measure the sensitivity of the system to tissue oxygenation changes. An oxygen probe was inserted via needle guidance to provide a reference measurement for tissue oxygenation. Ultrasound and PA Imaging was also performed on the forearm of a human volunteer in an IRB-approved case study.

Results

Renal Oxygenation Mapping in Rat-porcine model

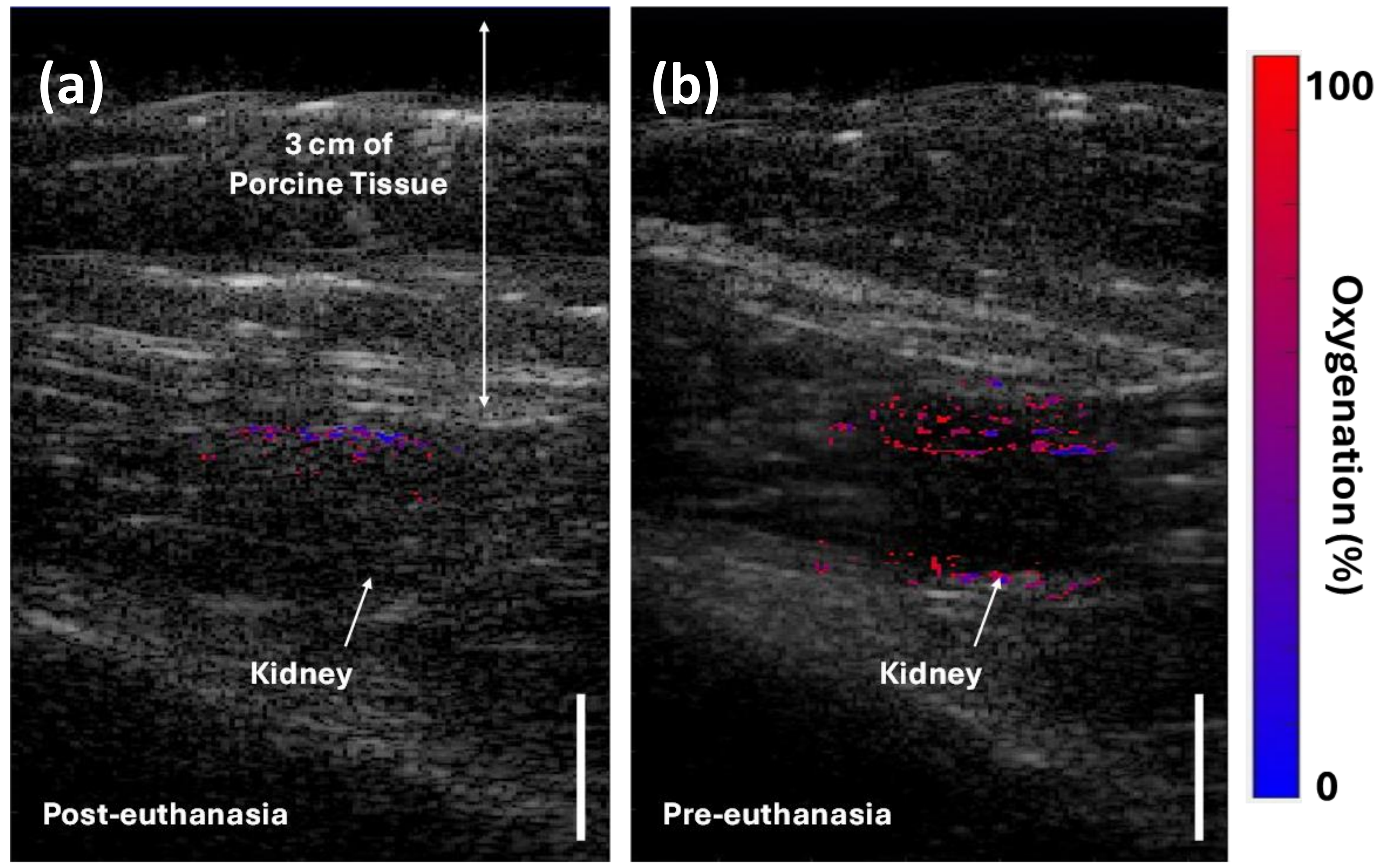


Figure 1: Assessment of renal oxygenation using NIR-II PLD-array. Oxygenation maps of pre- (a) and post- (b) euthanasia at 3 cm imaging depth overlayed on the corresponding B-mode images.

Imaging of human forearm

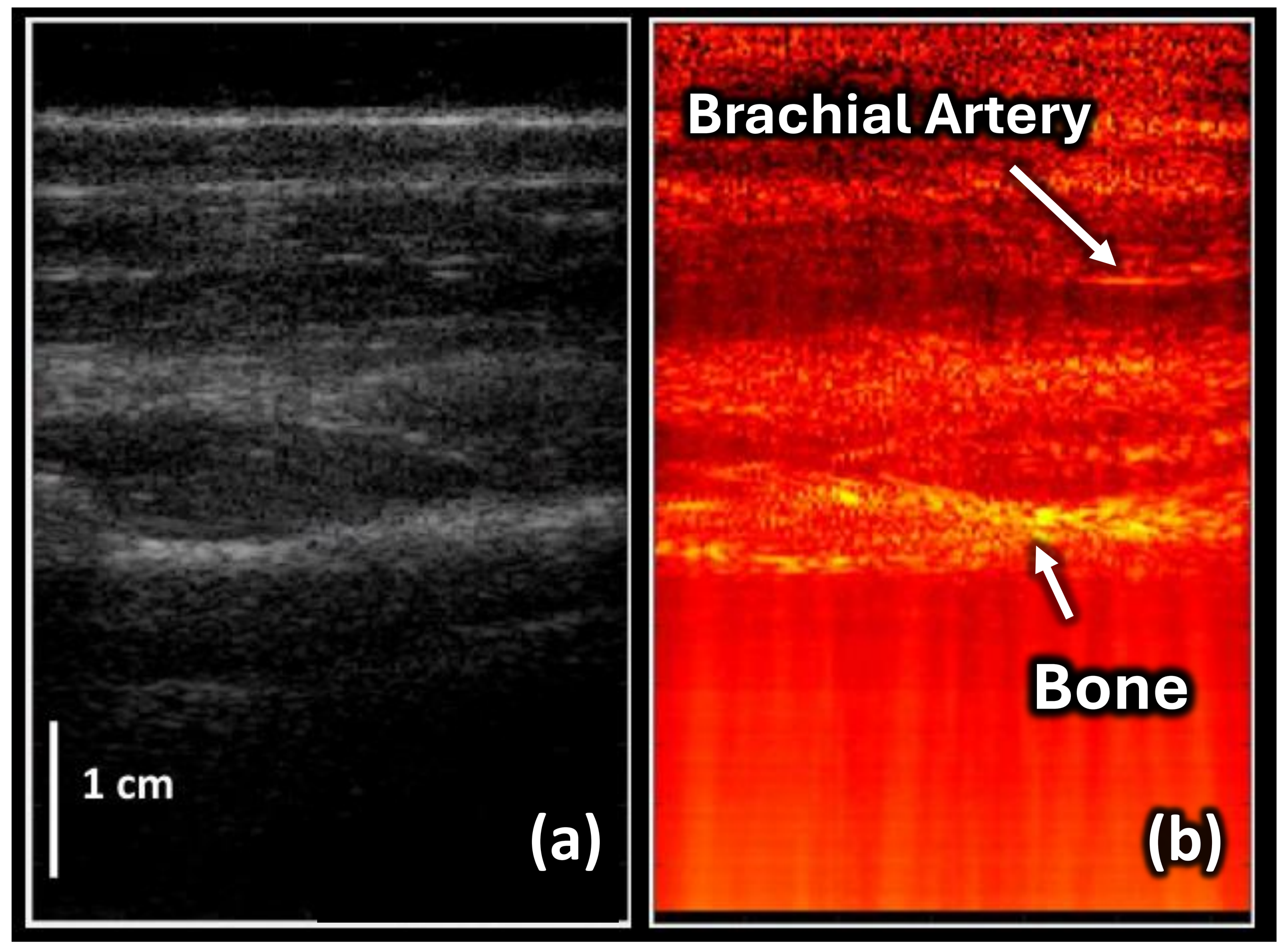


Figure 2: Ultrasound (a) and PA image (b) of forearm acquired with the PA probe prototype. PA signal is visible in highly vascularized regions and bone marrow.

Discussions

- **Detect DTPI before it becomes visible:** PA imaging maps deep-tissue oxygenation several centimeters below intact skin, enabling clinicians to identify early hypoxia at high-risk sites (sacrum, heel) during patient intake.
- **Feasible path to bedside DTPI assessment:** PLD based PA system shows reliable deep-tissue signal detection up to ~4 cm, supporting its potential as a handheld bedside tool to guide early intervention and off-loading decisions.

For more information

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