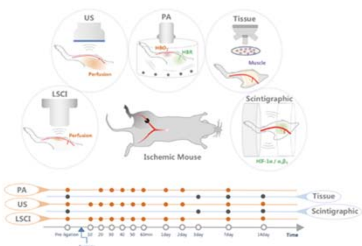
Vascular Recovery in a Preclinical Model of Peripheral Arterial Disease

Camille Moulin*, Tashiya Warfield*, Denise Medina, Jamila Hedhli, Wawrzyniec Dobrucki.
Carle Illinois College of Medicine, EBICS, Department of Bioengineering
University of Illinois at Urbana-Champaign, Urbana, IL 61801

Introduction

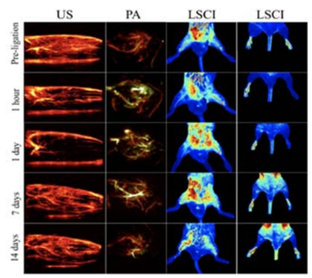
- PAD is a linked to several diseases and can eventually lead to amputation and/or death. It is estimated to affect 27 million people in Europe and America.
- In the past, treatments have been to change lifestyle, medication, or the use of a medical procedure.
- The proposed solution implements a multi-faceted non-invasive imaging approach, with the goal of monitoring and quantifying blood perfusion recovery.

Methods

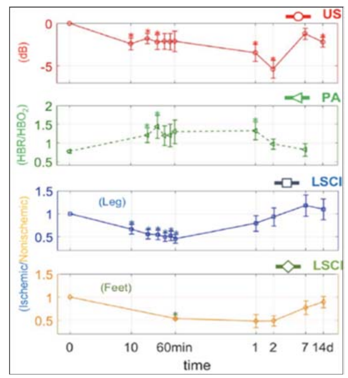


The right femoral artery was ligated to mimic PAD. The animals were serially evaluated using SPECT and assessed for perfusion using Ultrasound (US), Laser Speckle Contrast Imaging (LCSI), and Photoacoustic Imaging (PA). At day 3, 7, and 14, skeletal muscle tissue was extracted for immunohistochemistry experiments.

Results



Multimodal imaging data presented at a series of time points prior to and following ligations. Each column shows how a different circulatory parameter changes over time as the mice recover. Prior to ligation, perfusion appears strong, with the exception of distal regions of the limb where the signal appears to be diminished (primarily due to acoustic attenuation).
Because the oxygenated (HbO2, (red)) and deoxygenated (HbR, (green)) forms of hemoglobin have different near-IR absorption properties, PA is able to detect the relative level of blood oxygenation.



Changes in perfusion and hypoxia over a logarithmic timeline. The points marked (o) and (□) are for perfusion estimates using US and LSCI, respectively. Points marked (ᐅ) indicate the ratio of deoxygenated to oxygenated hemoglobin (HbR/HbO2) as measured via Photo-Acustics. The mark (*) above each point indicates a statistically significant ($p < 0{:}05$) difference from the preligation state.

Conclusions

Employing a novel Power Doppler US methodology enables the early detection of PAD without exogenous contrast agents while also using low-cost instrumentation commercially available today.
Through the integration of a variety of other non-invasive imaging modalities, we were able to visualize and quantify the spatiotemporal dynamics underlying vascular recovery through blood perfusion and oxygenation analysis non-invasively.

Future Directions

- ❖ This multimodal imaging assessment tool can be implementer in various therapeutic interventions:
  - Stem Cells
  - Gene Therapy
  - Pharmacology Studies
- ❖ Develop a better understanding of molecular interactions.
- ❖ Implementation as an earlier diagnostic tools.
- ❖ Improve individuality of treatments.
- ❖ Aid in producing a more confident diagnosis.

Acknowledgements: This work was supported by the Carle Illinois College of Medicine, the Emergent Behaviors of Integrated Cellular Systems (EBICS) NSF STC Grant, and the Department of Bioengineering.