Developing and testing a clinically translatable method to rapidly assess local cerebral blood flow using EIS

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Introduction & Research Question

Changes in the local cerebral blood flow are significantly correlated to the electrical activity of the neurons in the blood vessels. Brain tissue is also known to be densely vascularized with microscale vasculature every few tens of micrometers in any direction [1].

The *research question* asked was : Is electrochemical impedance spectroscopy a reliable method to assess relationship between different frequencies and samples using a three-electrode system.[2]

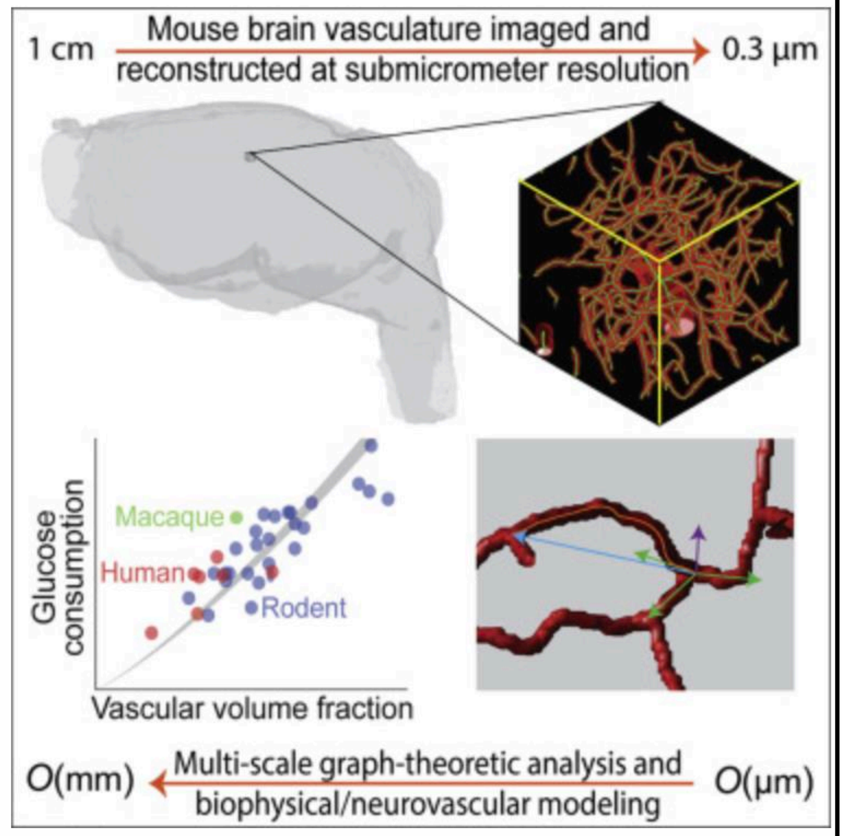

Fig 1 : Microvasculature of mouse brain showing heterogeneity in all directions [1].

Materials

A **3-electrode system** was used to record the EIS. Electrodes were standardized with equal lengths (2 inch each).

Electrode Fabrication & Laser Doppler : Tungsten working, platinum counter and silver reference (Ag/ AgCl) electrodes were used to run EIS on CH instruments electrochemical station.

Setup : 3-D printed electrode holder was attached to the stereotactic apparatus to ensure uniform placement of the electrodes during every run.

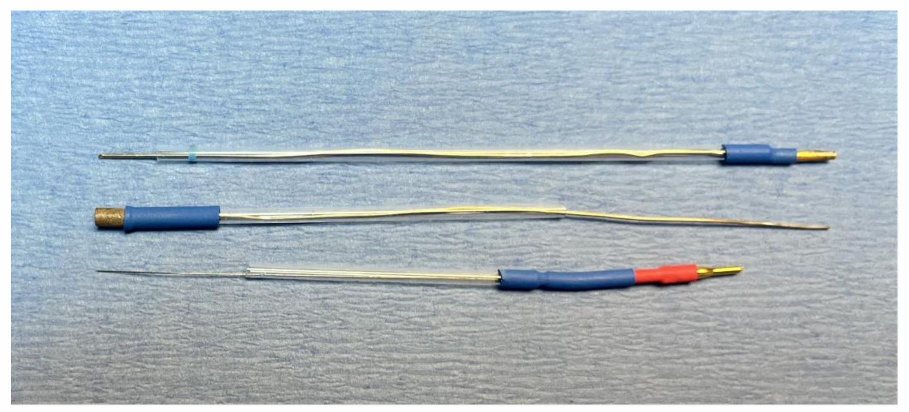

Figure 2 : Tungsten (red), Platinum-Iridium and Ag/AgCl electrodes used for EIS measurements.

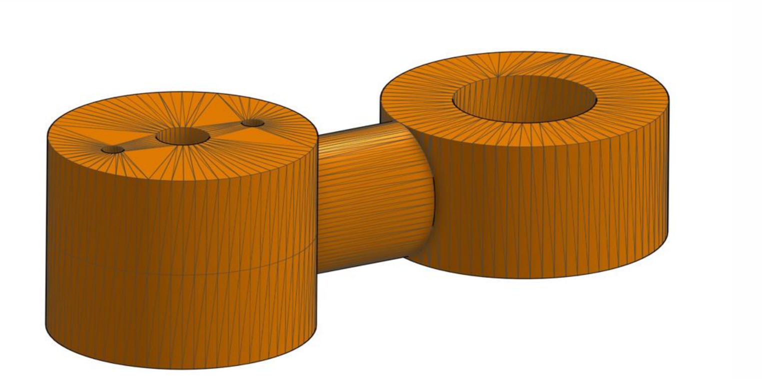

Figure 3: CAD model of the apparatus used to hold the 3-electrode system.

Methods

- **Animal Model :**
- Sprague-Dawley rat (200-300 g), underwent craniotomy (dura was removed).
- A dose of 5% isoflurane (2% maintenance) was used.
- Tungsten working, Platinum counter and Silver reference electrode system was administered.
- **EIS specifications :**
- Frequency range using 3-electrode setup : 100 Hz – 10kHz.
- Peak voltage used : 5mV
- **Baseline recording and inducing vasoconstriction :**
- Two baseline measurements (50 sweeps for each run) were taken before administration of 3 μL ET-1 of 20 μmol/L. Each baseline EIS lasted for 4 minutes and 30 seconds.
- Consecutive ET-1 doses were administered with interval of 1 minute between each administration.
- ET-1 dose was delivered below the site of laser doppler recording. This was done to target region directly below the laser doppler to undergo vasoconstriction.

Fig 4: Working electrode along with reference electrode employed in-vivo at the craniotomy site.

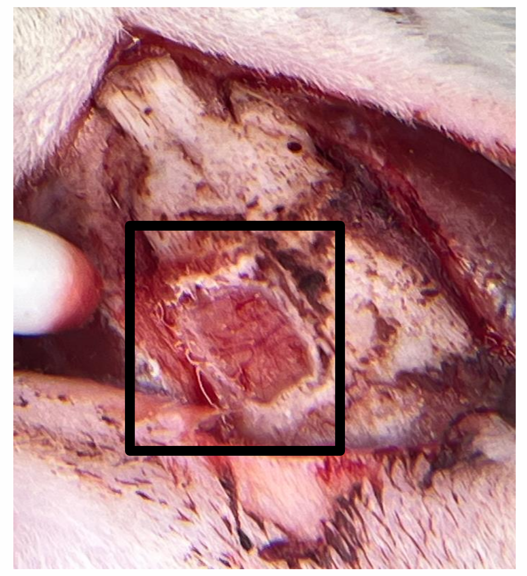

Fig 5: Craniotomy performed between bregma, and lambda left to the sagittal suture.

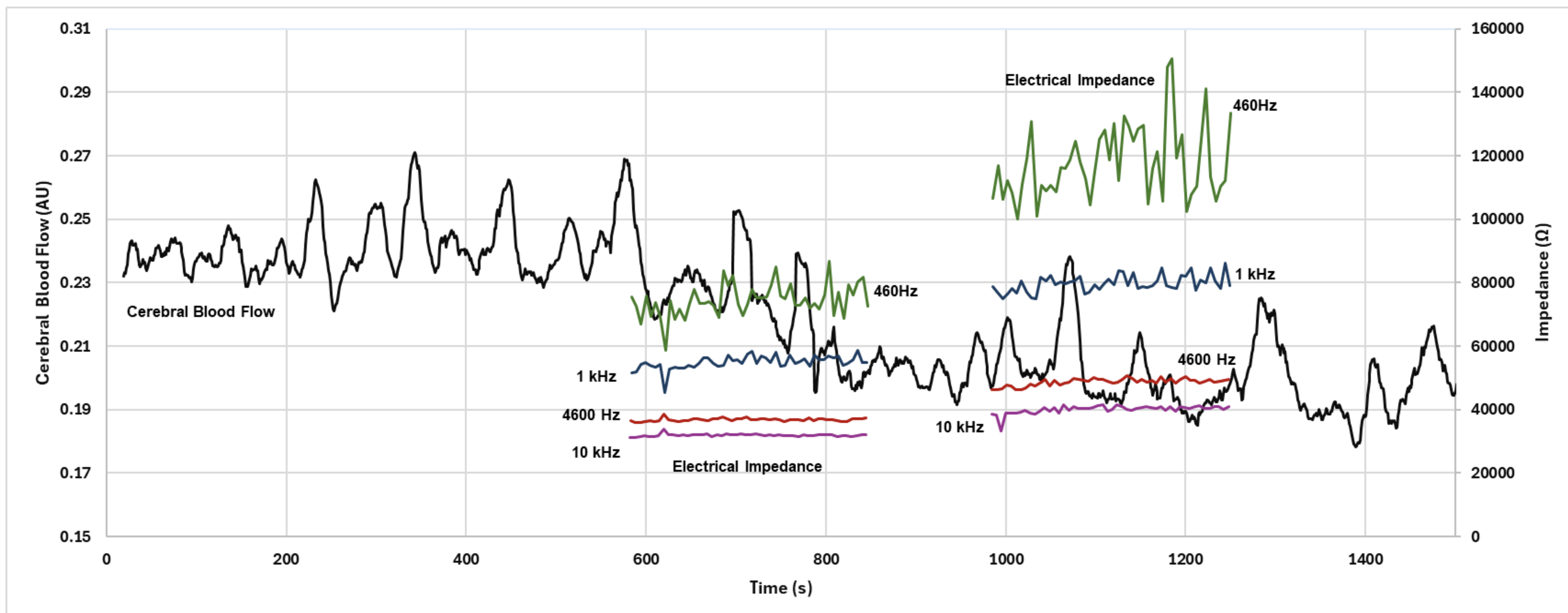

Fig.8. Plot showing changes in both local cerebral blood flow from the laser doppler flow probe and electrical impedance of brain tissue at 460 Hz, 1 kHz, 4600 Hz and 10 kHz plotted as a function of time. Increase in electrical impedance coincides with decreasing blood flow.

Discussion

- Electrical impedance across a range of frequencies tracked changes in blood flow in the femoral artery (approx. 0.65 +/- 0.15 mm in diameter).
- Baseline measurements from rat cerebral cortex with vascular diameters (ranging 20-50 μm) show correlations between changes in blood flow and electrical impedance suggesting our hypothesis translates across a range of vascular diameters and densities.
- However, we did not see significant change in the local cerebral blood flow in response to ET-1 injection in the brain tissue. This can be attributed to many reasons as follows –
- ET-1 did not reach the vasculature beneath the laser doppler flow probe.
- Volume and concentration of ET-1 may have been inadequate.

Conclusion & Future Work

Changes in electrical impedance across a range of frequencies correlates with changes in local blood flow over a range of vascular dimensions.

Future work would include adjusting the electrode setup after baseline runs to ensure the laser doppler is placed right above the brain tissue.

This would ensure ET-1 spreads to the region of brain tissue being sampled by the laser doppler flow probe.

Different doses of ET-1 will be used for different experimental cohorts to derive correlation and validate the same.

Acknowledgements & References

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[1]X. Ji *et al.*, "Brain microvasculature has a common topology with local differences in geometry that match metabolic load," *Neuron*, vol. 0, no. 0, Mar. 2021, doi: https://doi.org/10.1016/j.neuron.2021.02.006.
[2]"Jitendran, Elizabeth | KEEP," *Asu.edu*, 2024. https://keep.lib.asu.edu/taxonomy/term/160249 (accessed Oct. 15, 2024).

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Summarize

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Hi Saee,
I approve the poster for FURI presentation.

Thanks.
Best regards
Jit

From: Saee Sarang Pangarkar (Student) <spangark@asu.edu>
Date: Monday, November 3, 2025 at 2:05 PM
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