Development of a Non-invasive Bioimpedance System to Detect Ischemic and Hemorrhagic Stroke

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Background

Rapid identification of ischemic and hemorrhagic lesions is critical in the care of cerebrovascular patients. The current paradigm for rapid identification of these lesions involves a detailed neurologic examination, high-quality imaging and potentially invasive intracranial monitoring. A system to be able to non-invasively identify ischemic and hemorrhagic lesions as they are occurring, quantify the size and location of the lesion and alert providers would facilitate quicker response time. This is especially critical in field triage of patients to medical centers capable of neurosurgical and endovascular intervention.

With the goal of rapid identification of hemorrhagic and ischemic lesions, we have developed a noninvasive bioimpedance-based intracranial mapping (BIM) system. The goal of this system is to identify and distinguish between ischemic and hemorrhagic lesions using surface electrodes on the skin. This capability will allow for closer monitoring of post-operative patients as well as improve triaging of patients by EMS teams to medical centers capable of neurosurgical and endovascular intervention.

What is Bioimpedance?

- Bioimpedance is a physiological property related to a tissue’s resistance to electrical current flow and its ability to store electrical charge.
- The electrical properties vary depending on tissue type and the tissue state (e.g. edematous vs. normally hydrated).

What is the BIM System?

- The bioimpedance-based intracranial mapping (BIM) system will include a small form-factor electrical impedance acquisition (EIA) module, a set of scalp electrodes, a custom set of soft palate and orbital electrodes.
- The BIM aims to utilize the change in bioimpedance due to a shift in tissue state to identify ischemic and hemorrhagic lesions.
- The goal of the BIM system is to graphically display data in real-time to assess for changing tissue states.

Results

Initial validation of BIM system using model lesions

- Initial testing done with models of ischemic and hemorrhagic strokes (n=4)
- Ischemic – Fogarty balloon
- Hemorrhagic – Injection of autologous blood
- ICP monitor and depth electrode used to monitor for changes intracranially

Development of true ischemic lesion model

- Positive result from model lesions necessitated development of true ischemia model
- Initial approach based on previous Yucatan model
- Same electrode setup for BIM
- No Fogarty balloon used
- Left sided pterional craniotomy with zygomatic resection
- Sphenoid wing drilled down to gain access to opticocarotid cistern

Figure 3. Validation model for ischemic and hemorrhagic events (n=4)

Figure 4. Surgical exposure of the anterior circulation

Future Directions

- The non-invasive BIM system can detect model ischemic and hemorrhagic strokes
- Successful development of a surgical true ischemia model
- Surgical approach is a viable and reproducible method of causing ischemic lesions

Conclusions

- Identification of ICA terminus and bipolar ligation
- ICA/MCA/ACA transected to create infarct
- Intraoperative CTA performed to evaluate flow

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