Development of a Wearable Intracranial Pressure Monitoring Device

Students: Ese Bowry, Marissa Hsu

Mentors: Joshua Liu, Dr. Chad Gordon, Dr. Mehran Armand

JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

LABORATORY FOR
Computational
Sensing + Robotics

Project Description

- Intracranial pressure (ICP) monitoring uses a device placed inside the skull
  - Monitor senses the pressure inside the skull and sends measurements to a recording device.
- Monitoring devices usually used in cases where brain swelling should be monitored
- Commonly used methods:
  - Placing a catheter into the ventricle
  - Inserting a small, hollow device into a space between the skull and brain
- Live data readings until device is removed

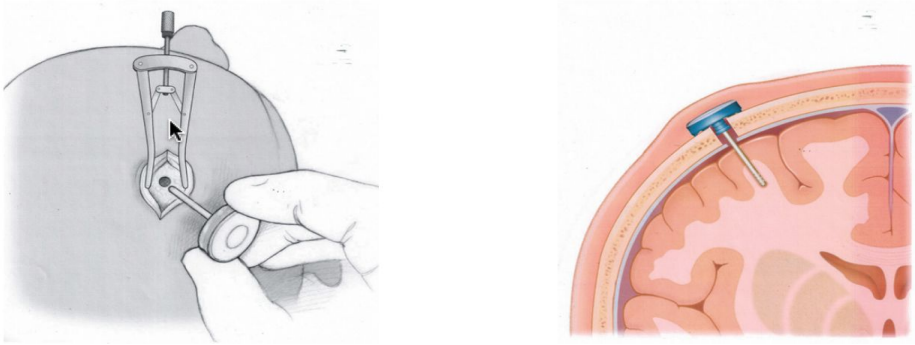
Intracranial pressure (ICP) monitoring system and connected external ventricular drainage catheter

Image source: https://www.researchdive.com/blog/intracranial-pressure-monitoring-device-and-its-critical-applications

Wireless ICP Devices

Branchpoint Technologies: AURA ICP Monitoring System

- System: implantable sensor, hand-held monitor, data receiver, antenna
- Monitor receives ICP data via RF telemetry
- Monitor relays the ICP waveform to a paired data receiver
- Manual process



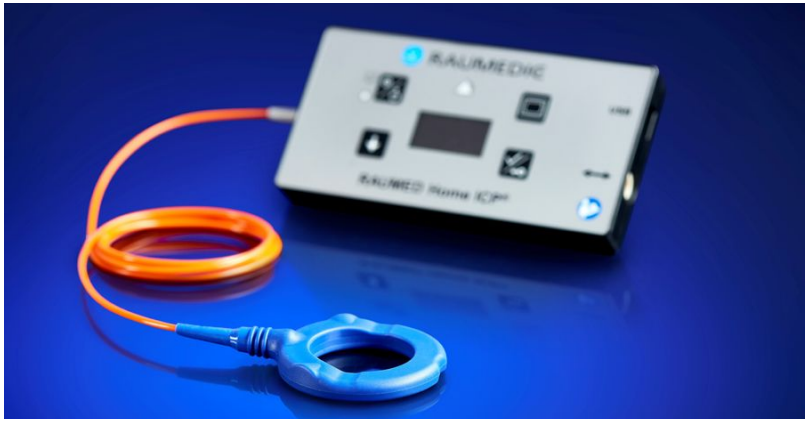
Insertion of AURA ICP Sensor at Kocher's point

Image source: https://fccid.io/2AJW6-BTAIS-01/User-Manual/User-manual-3452132.pdf

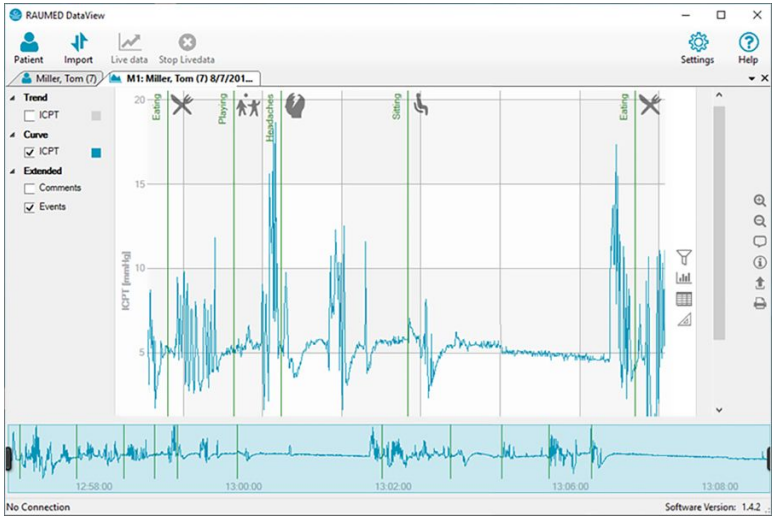
Wireless ICP Devices

Raumedic: Raumed Home ICP

- System: implanted catheter, circular reader antenna, user OLED display
- Patient is free to move about in his/her home
  - Self-track activities
- ICP data transmitted to physician upon clinical visit
- Long term ICP measurement



Circular reader antenna and user display



Software application for ICP waveform

Images source: https://rhi.raumedic.com/

Goals and Significance

Goals:

1. Prototyping a **wearable monitoring device** that can be embedded in a cranial implant for measuring a patient's intracranial pressure
2. Transferring the **data** to a remote PC/smartphone via Bluetooth/Wifi
3. **Live-tracking** and feedback

Significance:

- Creation of a singular system that extracts the most efficient and effective components of previous/current devices will not only be user friendly but advance ICP telemedicine techniques

Technical Approach

Implantable ICP Device

- FLORA - Wearable Electronic Platform (Arduino)
- 3D-printed cranial implant
- Bluetooth Transmitter

Interface

- iOS App
- Live data collection and presentation
- Pressure warnings

Image Source: https://www.hopkinsmedicine.org/neuroplastic-surgery/

Deliverables

Minimum:

- Functional Monitoring Device using FLORA Wearable Electronic Platform
- iOS App for ICP monitoring

Expected: Minimum +

- GUI
- ICP monitoring with specified pressure (high) warnings
- Usability testing
- Documentation

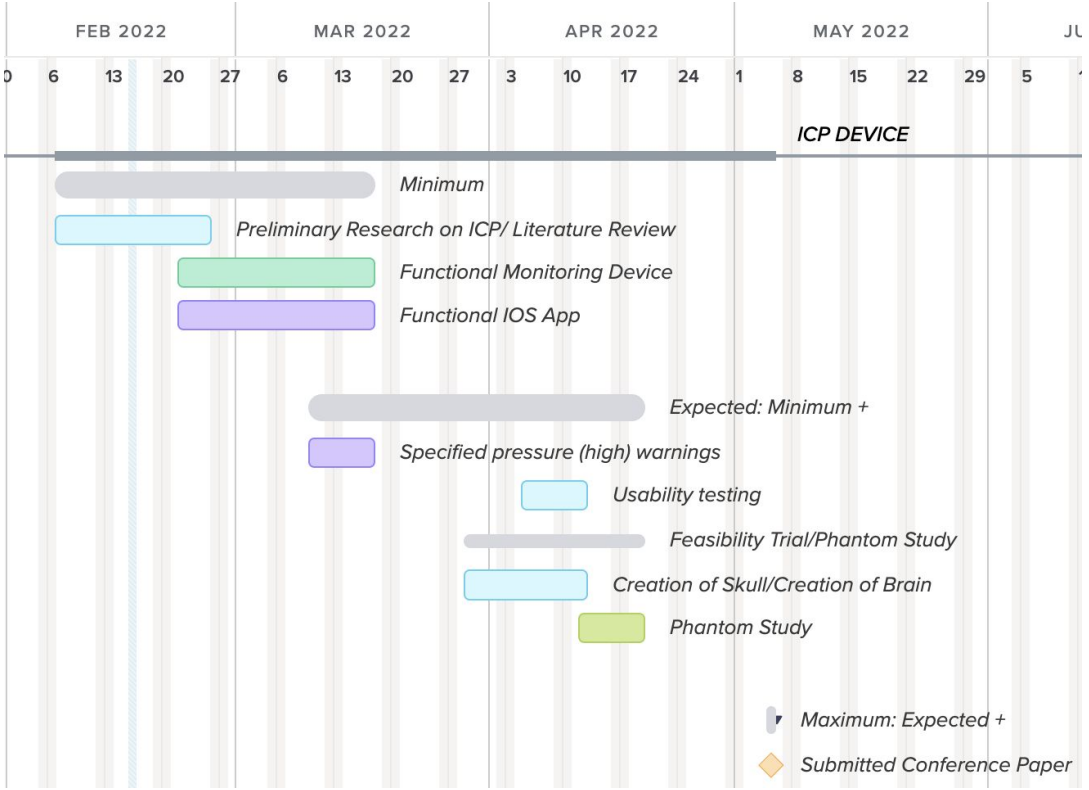
Maximum: Expected +

- Submitted Conference Paper

Milestones

- Fully functional ICP monitoring device and iOS App
- Creation of Fake Skull and Brain (Fabrication - 3D printing, molding, etc)
- Feasibility Trial/Phantom study
- Usability Testing

Timeline


FEB 2022
MAR 2022
APR 2022
MAY 2022
JU
0 6 13 20 27 6 13 20 27 3 10 17 24 1 8 15 22 29 5
ICP DEVICE
Minimum
Preliminary Research on ICP/ Literature Review
Functional Monitoring Device
Functional IOS App
Expected: Minimum +
Specified pressure (high) warnings
Usability testing
Feasibility Trial/Phantom Study
Creation of Skull/Creation of Brain
Phantom Study
Maximum: Expected +
Submitted Conference Paper

Dependencies

Dependency	Solution	Alternative	Expected Date	Status	Effect
Obtaining Electronic Component	Purchasing FLORA Wearable Electronic Platform	Purchasing Bluefruit LE Module	2/21/2022	Completed	Unable to begin design of device
Data Transfer	Purchasing Bluetooth Transmitter	Purchasing Wifi Module	4/1/2022	Not Started	Wireless Transfer
Fake Skull	3D Printing/Molding	Plastic Skull	4/12/2022	Not Started	Full Testing
Testing Environment	Fully Functional Device and App	Minimally Functional Device+App	3/17/2022	Not Started	Usability Testing and Improvements

Management Plan

- Meetings:
  - Mentor: Mondays
  - Team: Wednesdays
  - Additional meetings as necessary
- Communication: Email
- Code Management: GitHub
- Documentation: Google Drive and CIS Wiki

Reading List

- Mitchell, K. S., Anderson, W., Shay, T., Huang, J., Luciano, M., Suarez, J. I., Manson, P., Brem, H., & Gordon, C. R. (2020). First-In-Human Experience With Integration of Wireless Intracranial Pressure Monitoring Device Within a Customized Cranial Implant. *Operative neurosurgery (Hagerstown, Md.)*, *19*(3), 341–350. https://doi.org/10.1093/ons/opz431
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