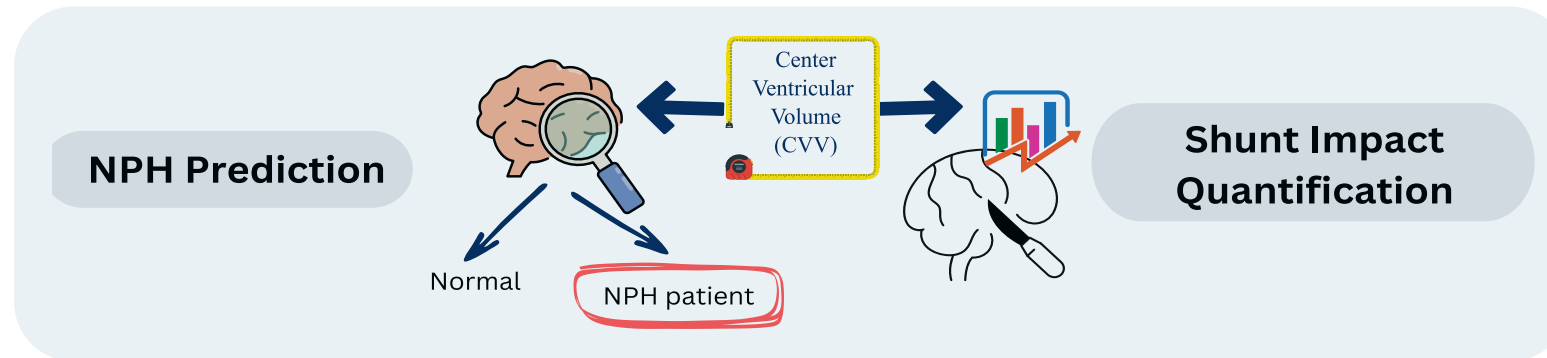# AI for automatic analysis of shunt treatment in pre- and post-surgery CT brain scans of iNPH patients

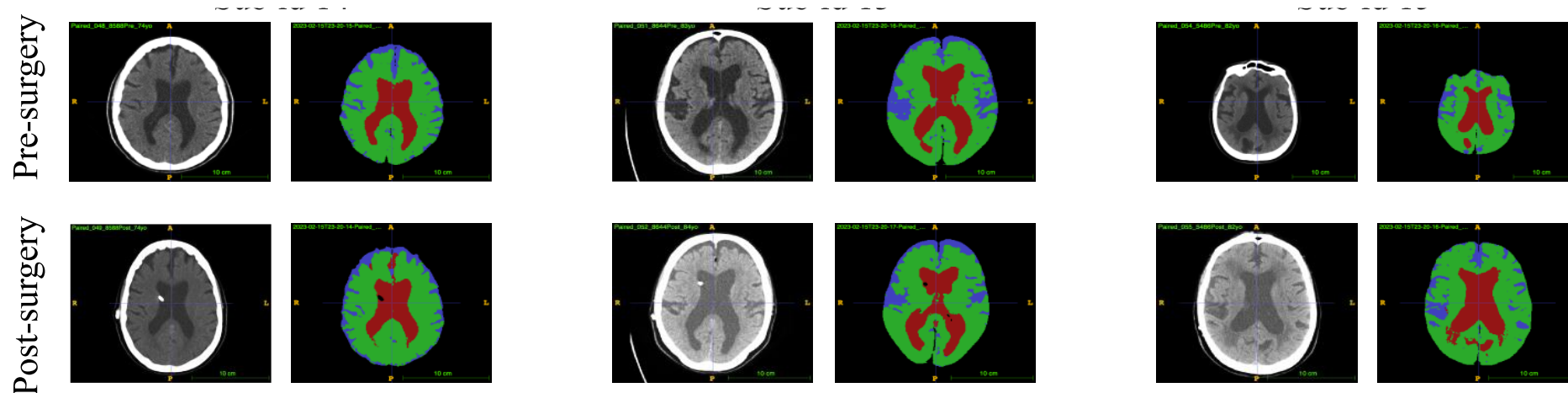**2024 COLLABORATIVE RESEARCH SYMPOSIUM**

Session II: AI & Innovation

S. Shailja[2], Christopher Nguyen[7], Chandrakanth Gudavalli[2], Jefferson W. Chen[7] and B. S. Manjunath[2]

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Objectives

- Ventriculo-peritoneal shunt procedures can improve Idiopathic Normal Pressure Hydrocephalus (iNPH) symptoms.

- Main goal of this research is
  - Quantify longitudinal changes in the ventricular volume and its correlation with clinical improvement in iNPH symptoms.
  - Develop an end-to-end graphical interface where surgeons can directly drag-drop a brain scan for quantified analysis.

Shailja, S., Nguyen, C., Thanigaivelan, K., Bhagavatula, V., Chen, J.W. and Manjunath, B.S., 2023. AI-based analysis of the shunt treatment in pre-and post-surgery computed tomography brain scans of iNPH patients. *medRxiv*, pp.2023-06. (Accepted in *Neurosurgery*)

Dataset

- The CT scans of adult patients who had a clinical and radiological diagnosis of iNPH from January 2015 to December 2022

- Data was collected from the UCI Medical Center NPH clinic.

- 47 scans from 15 patients (7 males and 8 females) that had undergone a ventriculo-peritoneal (VP) shunt ranging in age from 70s to 90s (mean = 78.5; SD = 5.2)

- At least one pre-operative CT scan of the brain was taken.

- Multiple post-surgery scans were taken in addition to the immediate post-operative scan.
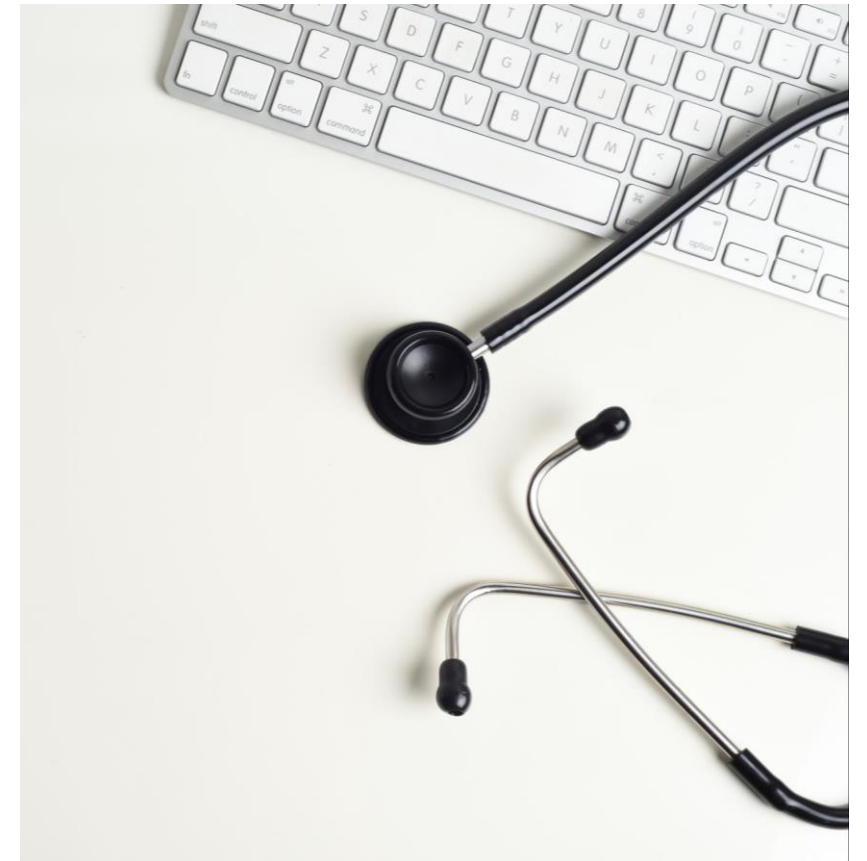
Proposed metric: CVV

- CVV is the normalized ventricular volume of the center slices (35mm axially).

- m slices are chosen before and after slice k* with the maximum ventricular volume.

- Center slices of the scan that are most representative (80%) of the ventricular volume.

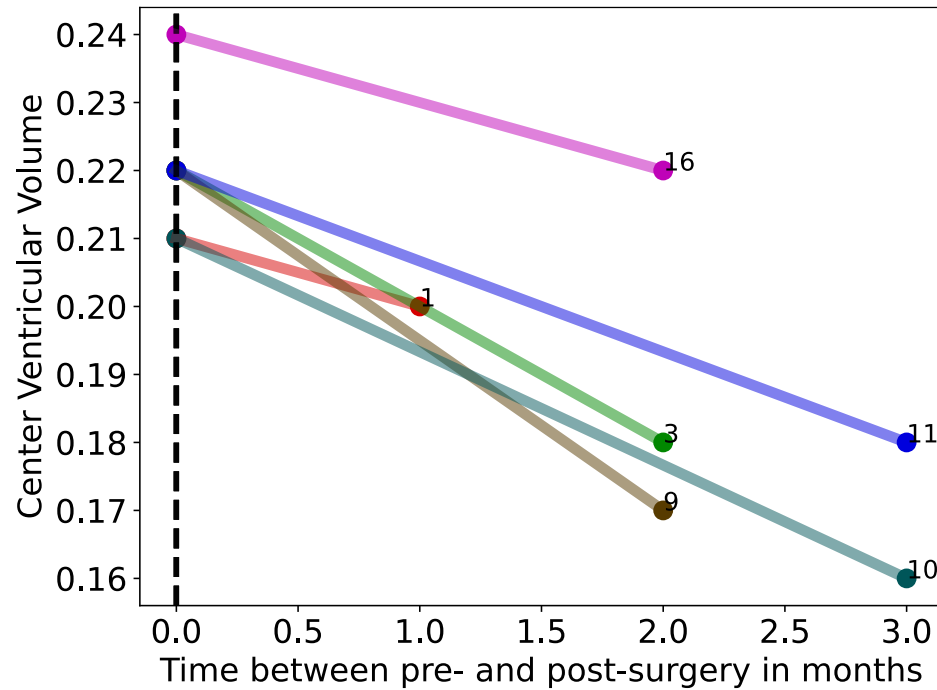$$I_{k^*-m} \quad I_{k^*-2} \quad I_{k^*-1} \quad I_{k^*} \quad I_{k^*+1} \quad I_{k^*+2} \quad I_{k^*+m}$$
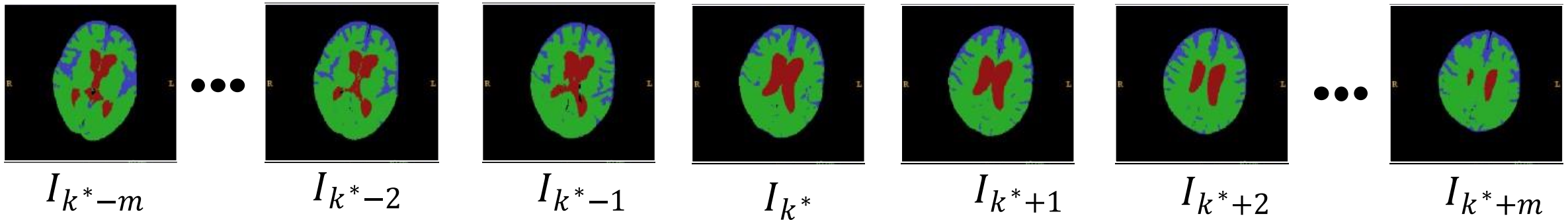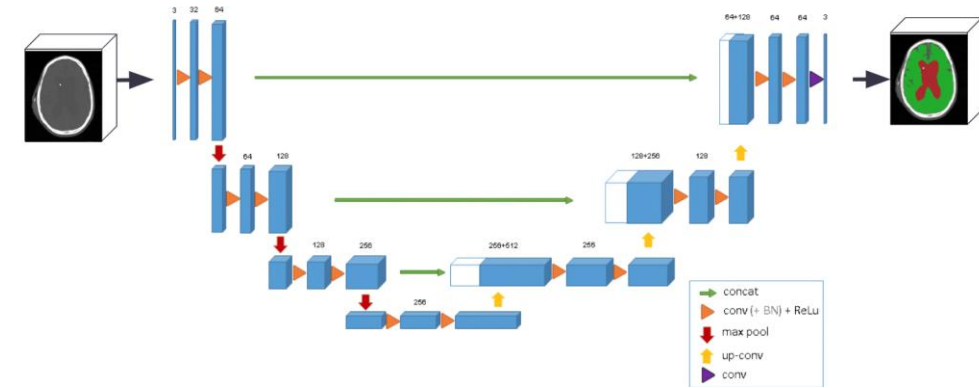
Volume of Ventricle and Subarachnoid

$$\text{Center Ventricular Volume (CVV)} = \frac{\text{Ventricular Volume in } 2m+1 \text{ slices}}{\text{Brain Volume in } 2m+1 \text{ slices}}$$

Zhang, A., Khan, A., Majeti, S., Pham, J., Nguyen, C., Tran, P., Iyer, V., Shelat, A., Chen, J. and Manjunath, B.S., 2022. Automated Segmentation and Connectivity Analysis for Normal Pressure Hydrocephalus. *BME frontiers*.

Impact of shunt surgery

All subjects with iNPH showed a positive response to shunt surgery.

Non-responders shows significant CSF drainage post shunt adjustment.
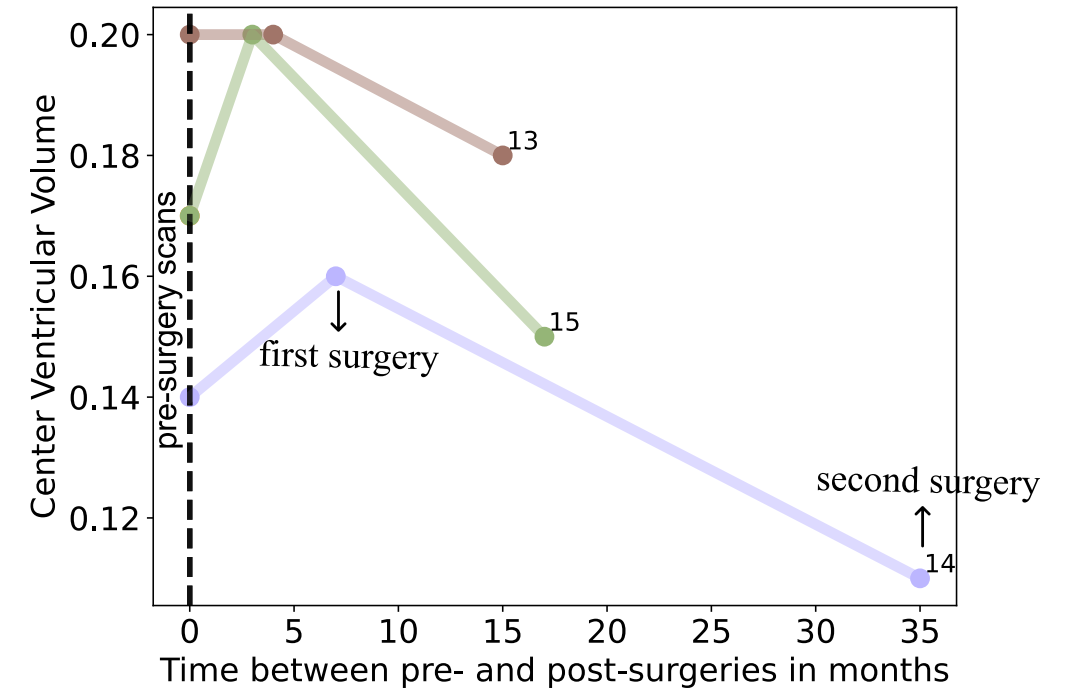
Longer term impact of shunt placement

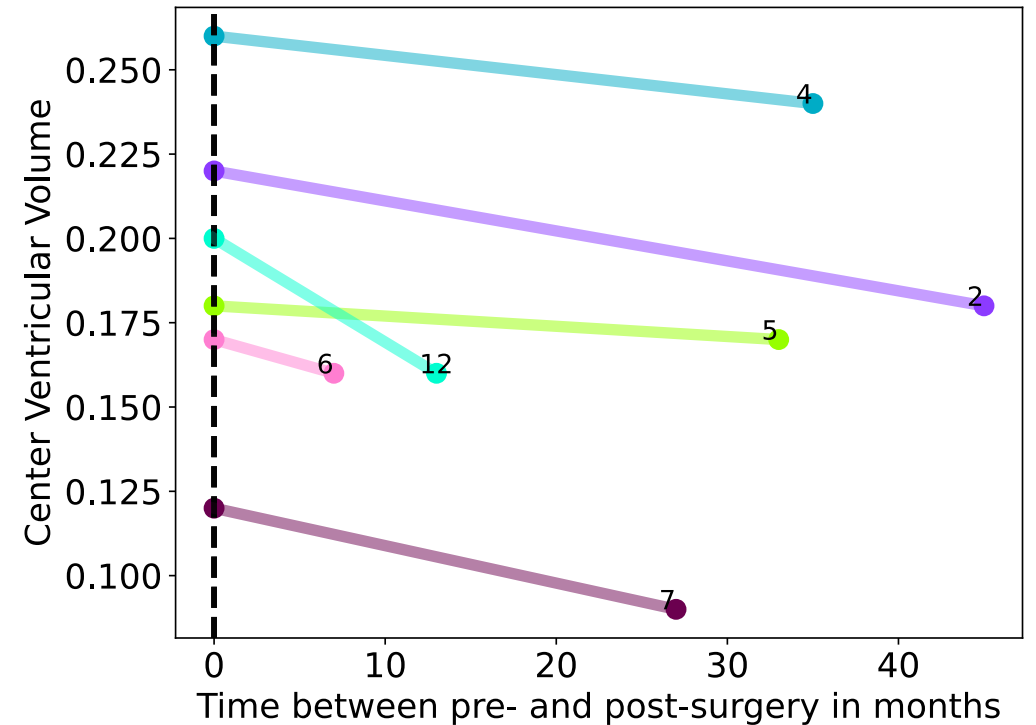This study includes subjects with time differences between pre- and post-scans ranging up to 40 months.

Quantitative validation of improvement in ventricular volume by CVV metric.

Common perception: Response to shunt surgery for iNPH is of limited duration.

Observation: Even after 3 months, the ventricular volume is lower than pre-scan.

Correlation between quantitative and qualitative diagnosis

- Absolute change in CSF for central ventricular volume in cc after shunt surgery correlates to the improvement in patients.

- The two smallest arrows (< 4cc CSF drained) are associated with worsening conditions in one of the symptoms of gait, cognition, or bladder control.

gait, cognition or bladder

Change in ventricular volume
in cm^3 after shunt surgery
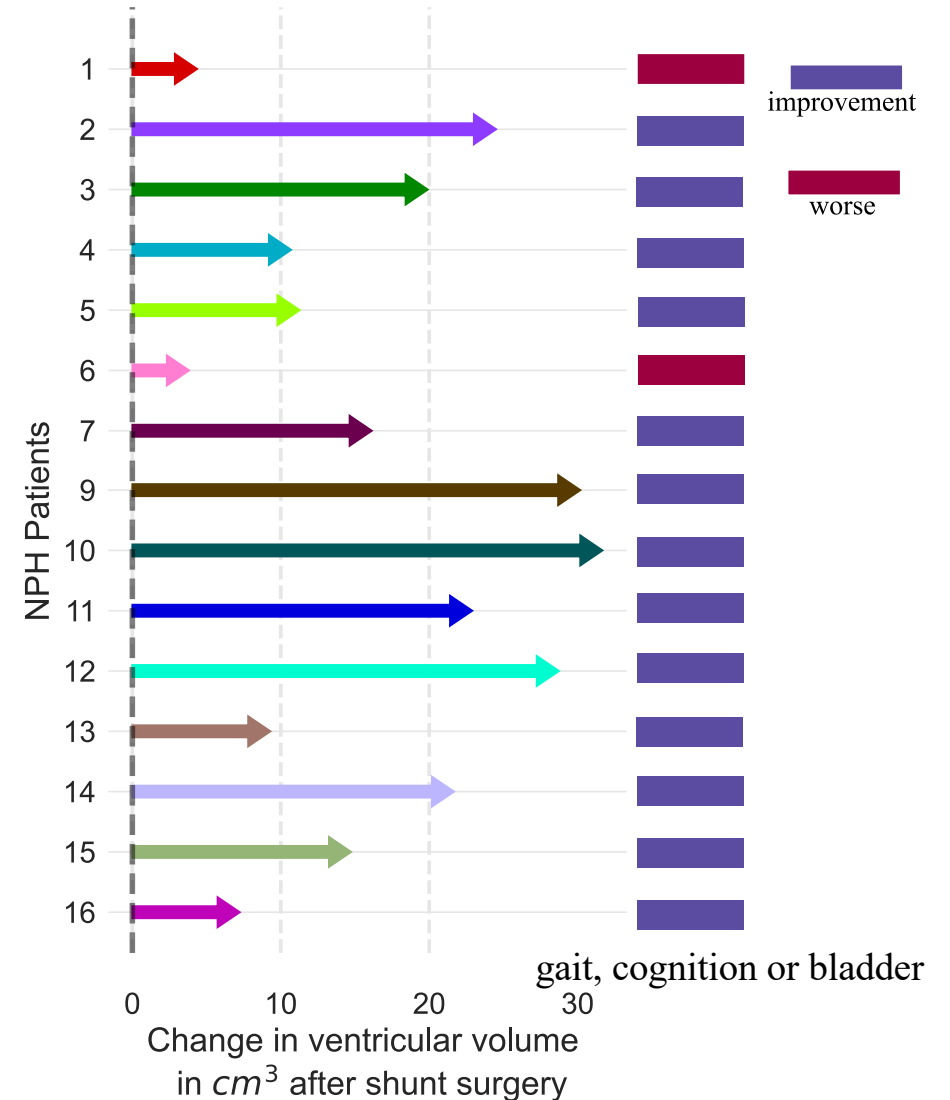
Try our web interface BisQue!

The user interface of the iNPH Analysis module hosted on BisQue:
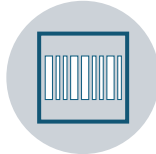
bisque2.ece.ucsb.edu

BISQUE: DRAG-AND-DROP SCANS FOR QUICK ANALYSIS.

REAL-TIME VOLUMETRIC OUTPUT

SIMULTANEOUSLY UPLOAD PRE AND POST SCANS

CLINICIANS CAN VISUALIZE SEGMENTED SCANS AND ACCESS METRICS.

IMPROVE INPH DIAGNOSIS FLOW!

Ongoing research

- Increase in ventricular volume affects the neuronal connection surrounding ventricles.

- How does structure distortion in such bundles correlate to gain, cognition, and bladder function?

- Dataset: Collaborate across multiple institution to collect Diffusion MRI for iNPH subjects.
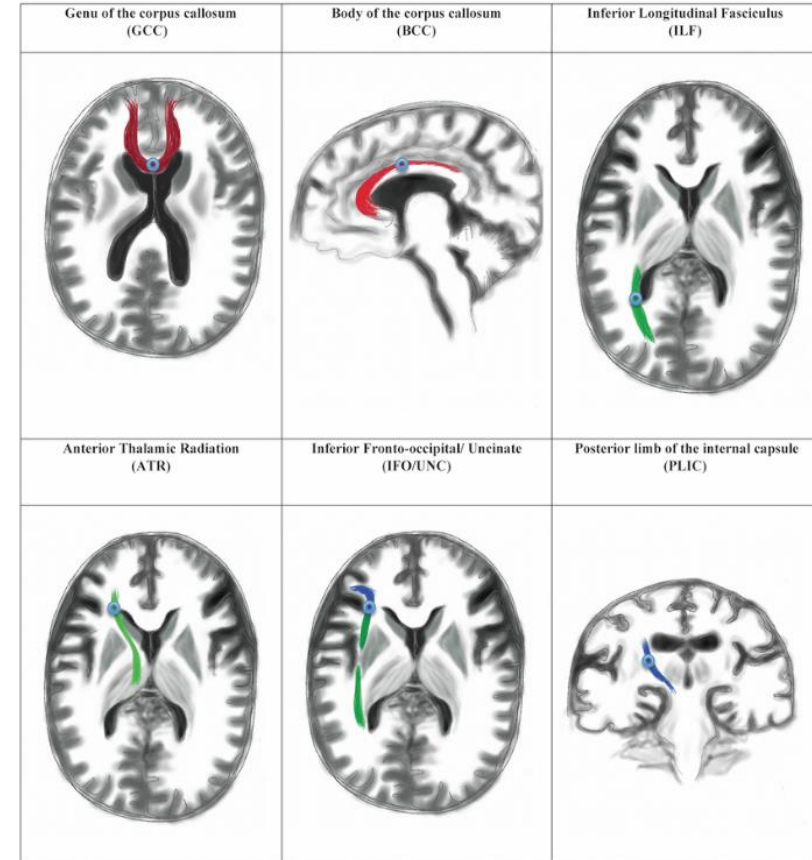

Illustration of white matter regions of interest (ROIs). White matter tracts represented in the context of normal ventricular size for clarity. https://doi.org/10.1371/journal.pone.0181624.g001

Shailja, S., Bhagavatula, V., Cieslak, M., Vettel, J.M., Grafton, S.T. and Manjunath, B.S., 2023. ReeBundle: a method for topological modeling of white matter pathways using diffusion MRI. *IEEE Transactions on Medical Imaging*.

Key takeaways

- Quantifiable changes can be detected in ventricular volume after VP shunt procedures.

- Our drag-and-drop style interface serves as a valuable clinical adjunct in enhancing patient care.

- Consistent performance across various institutional scanner types!

- More CT brain scans can improve the model!