MECHANICAL 3-D MODEL FOR NEURO-ENDOSCOPIC SURGERY SIMULATION

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Background

- 4 brain ventricles
- Function: Cerebrospinal Fluid (CSF)
  - 400-500mL/Day
- CSF protects the brain and spinal cord
  - Nutrients

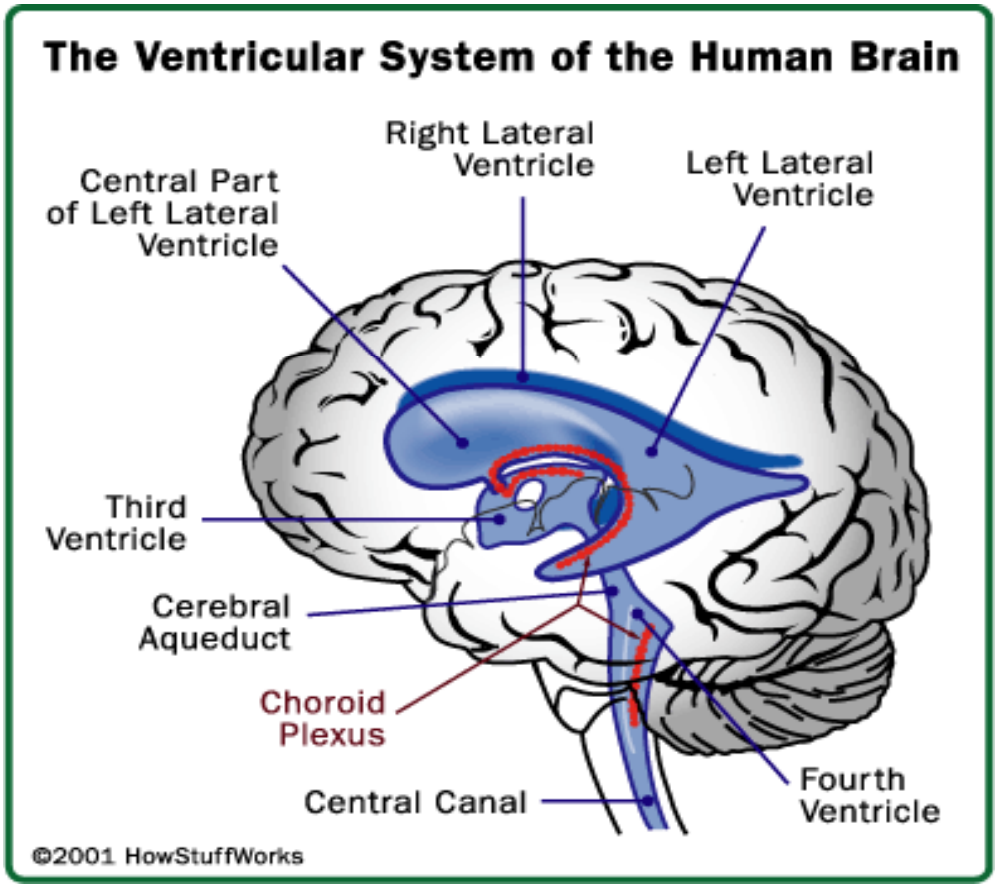
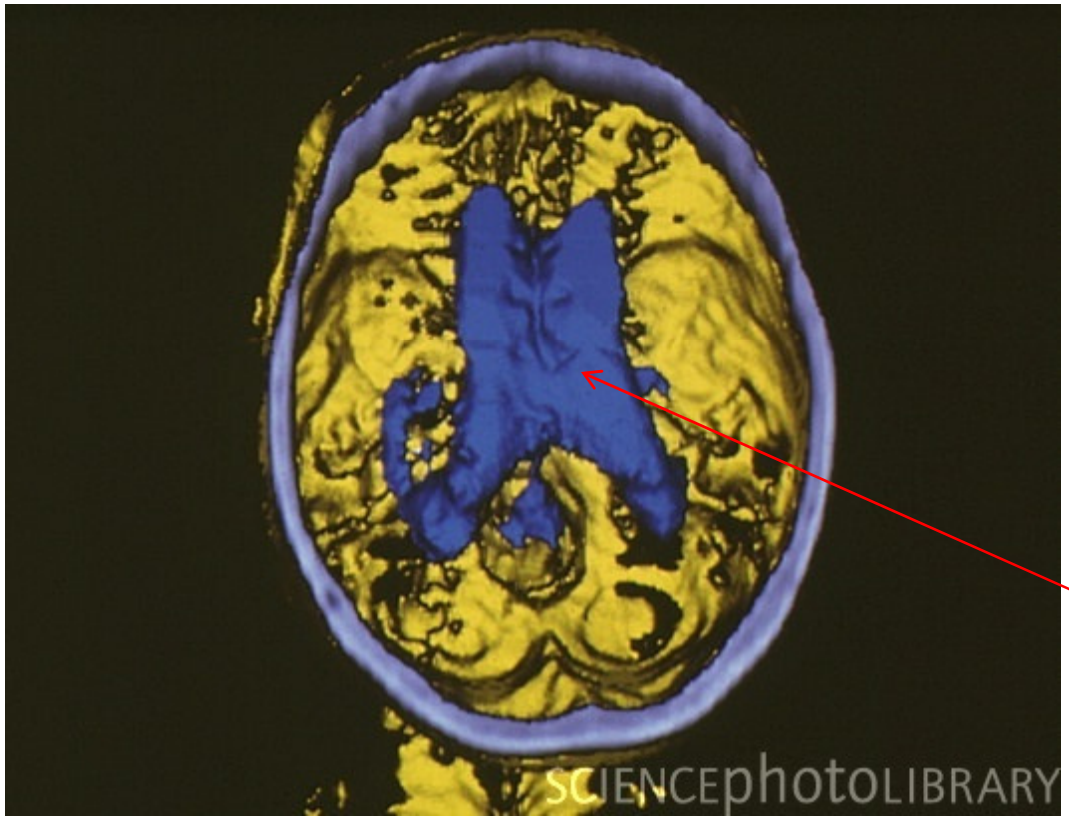


Figure 1: A representation of the human ventricular system

<http://static.howstuffworks.com/gif/brain-ventricles.gif>

Ventricular system (top)



Ventricular System

Figure 2: Top View of Ventricles

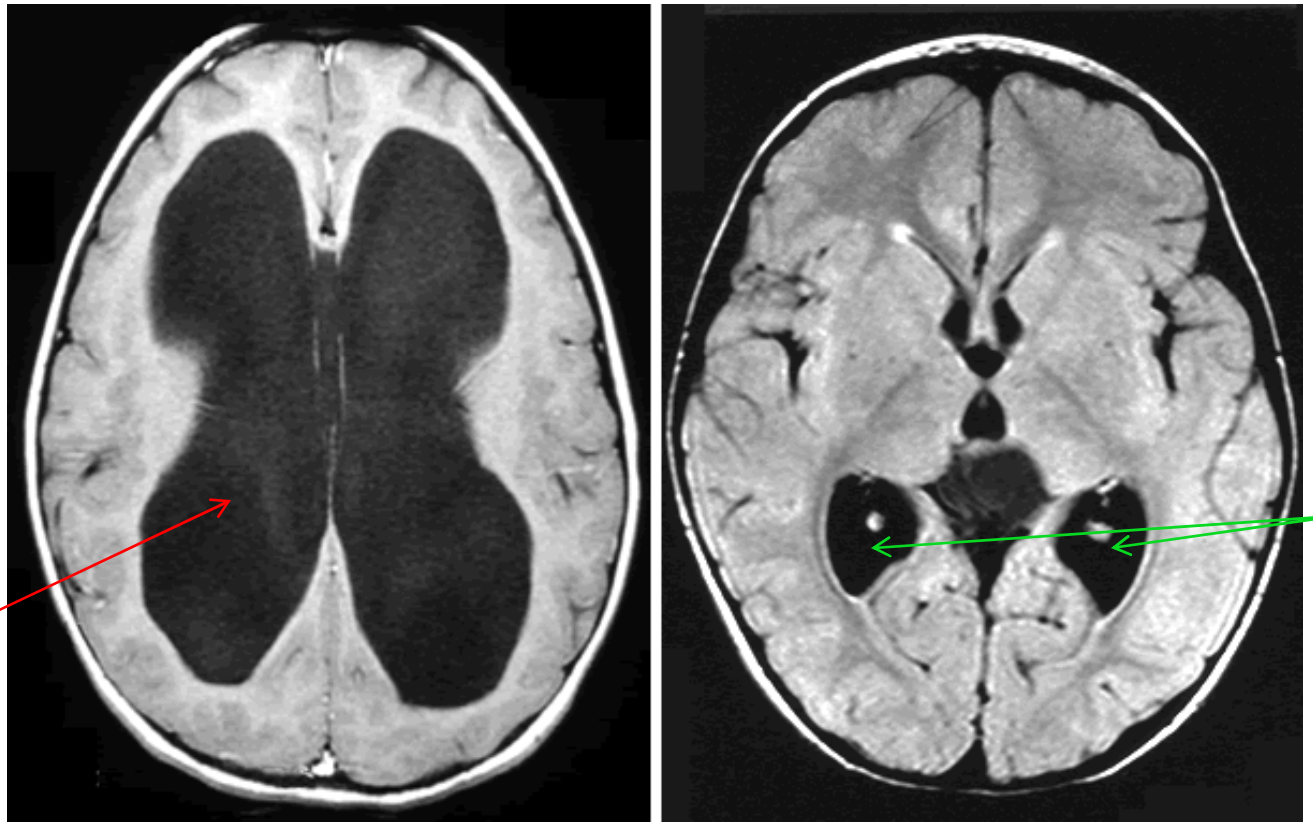
<http://www.sciencephotolibrary.com/images/download_wm_image.html/P332147-False-colour_3-D_CT_scan:_ventricles_of_the_brain-SPL.jpg?id=803320147>

Hydrocephalus

Figure 3: A hydrocephalic baby
<http://www.chinalittleflower.org/images/babies/Chun%20Xin.JPG>

- Blockage in CSF flow
- Common in Cerebral Aqueduct
  - Tumor, Cyst, Tissue Malformation, Granular Material
- Swelling
- Pressure on brain
  - Brain damage
  - Cognitive impairment

Hydrocephalic brain



Enlarged hydrocephalic lateral ventricles

Normal size ventricles

Figure 4: Hydrocephalic MRI (Left) compared to normal MRI (Right)

<http://www.seattlechildrens.org/uploadedimages/Seattle_Childrens/cmsassets/Images/hydrocephalus-normal-non-normal-ct-scans_large.gif>

Endoscopic Third Ventriculostomy

- Surgery to release pressure
- Utilizes an endoscope
- Puncture 3rd ventricular floor
- Stent allows CSF drainage

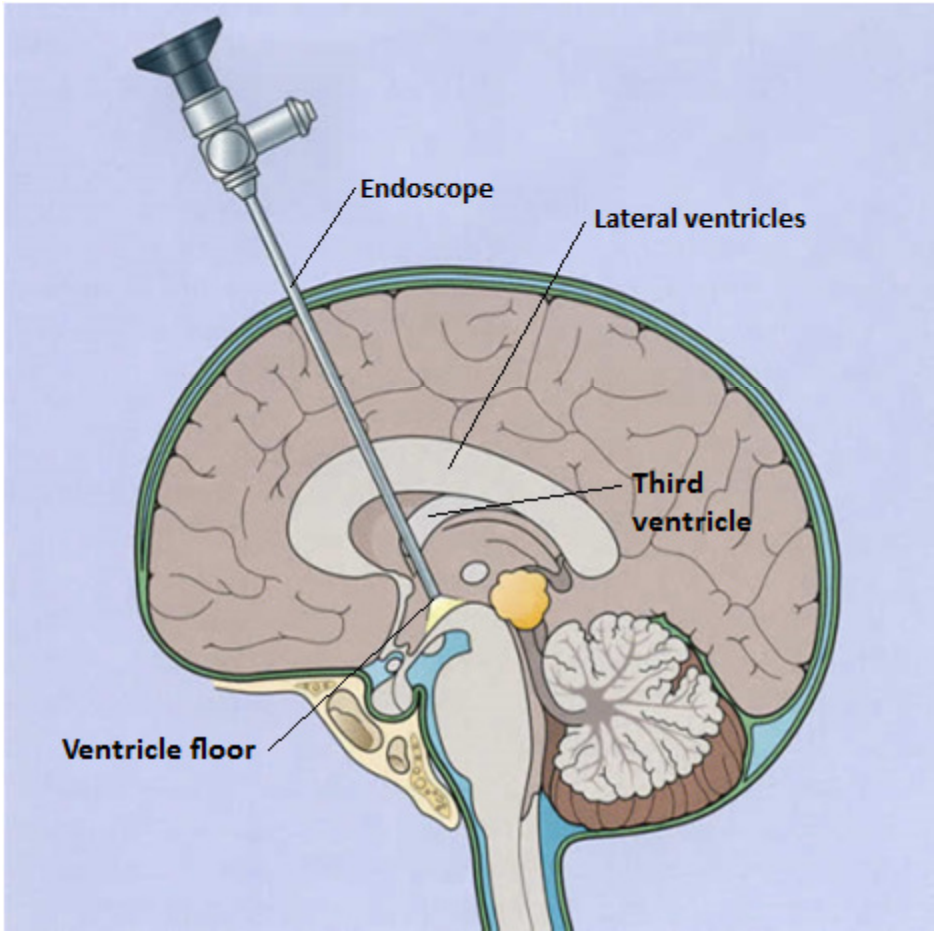


Figure 5: An endoscope inside the brain.
<http://www.seattlechildrens.org/uploadedimages/Seattle_Childrens/cmsassets/Images/endoscope_large.jpg>

Motivation

- No models for endoscopic third ventriculostomy
  - Mechanical
  - Computer Simulation
- Cadavers currently method of practice
  - Stiff texture and shrunken ventricles
- Actual surgery should not be first practice

Problem Statement

- Teaches medical students to perform endoscopic third ventriculostomy
- Currently no viable model for teaching and practice
  - Not specific to endoscopic third ventriculostomy
- Model is required to:
  - Train medical students
  - Patients are not subject to inexperienced surgeons

Client requirements

- Allow practice of Endoscopic third ventriculostomy
- Resemble hydrocephalic brain
  - Anatomy
  - Texture
- Flexible and disposable
- Include endoscope entry and ventricle floor
- Compatible with rigid endoscopes of diameter 6mm

Design 1: Enclosed Ventricular System

- Pre-assembled model
  - Flexible
  - Fluid included
  - Realistic detail
- Disposable
  - Easily reproduced
  - Multiple practices
    - Endoscope entry
    - Puncturing ventricle floor

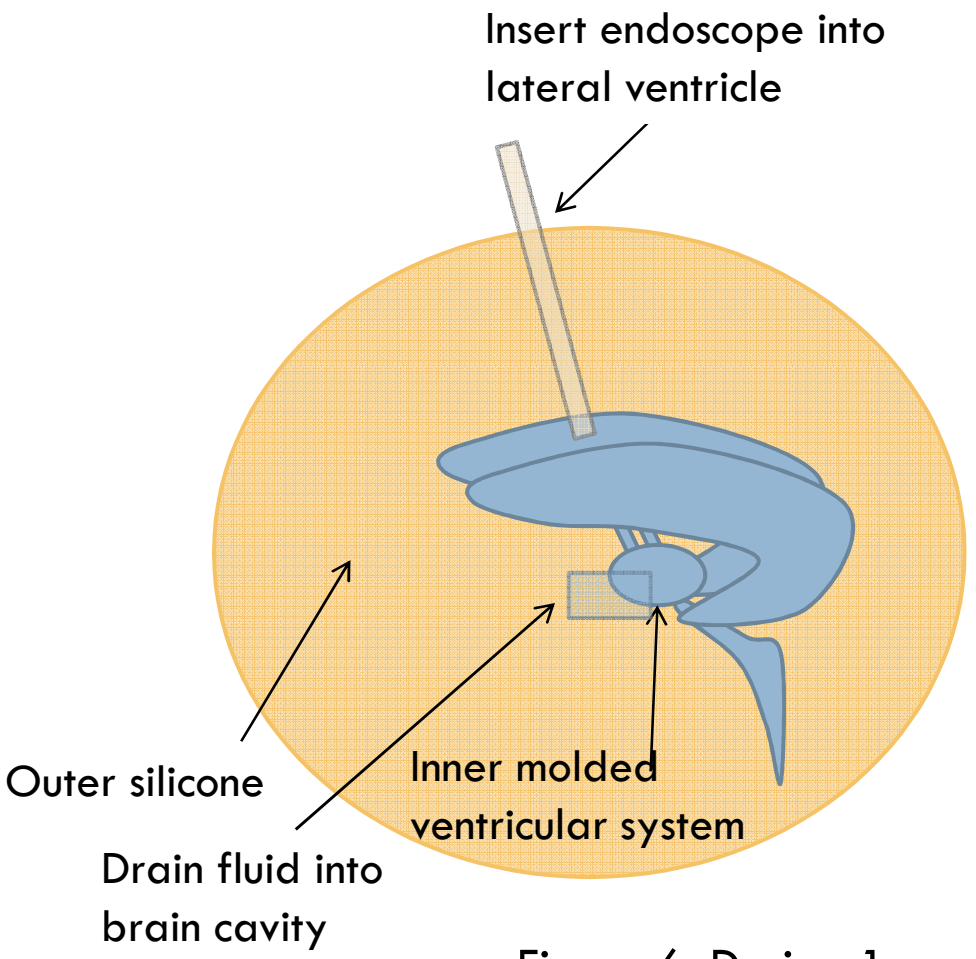


Figure 6. Design 1

Design 2: Capped Ventricles Model

- Cap outside of third ventricle floor
  - Prevent fluid leakage
  - Puncture and stretch ventricle floor
- Flexible material
  - Insertion of endoscope
- Valve system
  - Introduce fluid using syringe

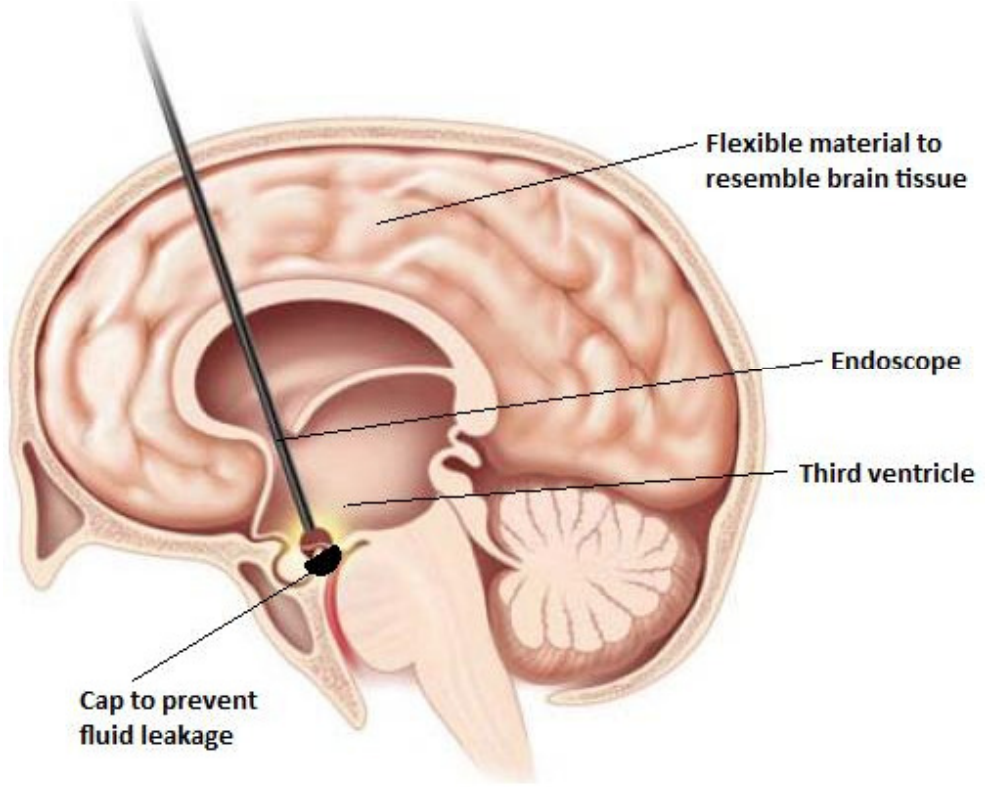
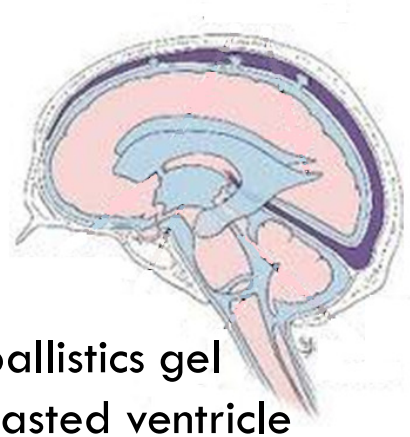


Figure 7. Design 2

Design 3: Ballistics Gel Model

- Ballistics gel cast around ventricles
  - Allows hollow cavities in model
  - Reusable
- Gel mold in skull around ventricles
  - Different consistencies
  - Realism
  - Retain mineral oil
  - Disposable and cheap



Pink = ballistics gel
Blue = casted ventricle spaces

Figure 8. Ballistics gel model. (LifeART, 2006).

Figure 9. Ventricle model <http://fsweb.bainbridge.edu/acunningham/AP/AP-Nerve.htm >

Design Selection Matrix

Design	Weight	Ballistics Gel Molding	Enclosed Ventricular System	Capped Ventricles Model
Accuracy	30	25	28	27
Teaching Effectiveness	30	28	28	24
Cost	20	18	13	14
Duplicability	10	9	7	7
Feasibility	10	9	8	8
Total	100	89	84	80

Table 1: Design Selection Matrix

Material Options

Material	Silicone	Urethane	PolyJet Gray	Tango Plus Fullcure 930	Ballistics Gel (Ballistics Gel Model)
Elasticity	5	5	5	4	5
Flexibility	4	4	3	5	4
Small Detail Capability	4	4	5	4	4
Fluid Compatibility	5	4	4	4	4
Total	18	17	17	17	17

Table 2: Material Selection Matrix

Final Design: Ballistics Gel Model

- Ballistics material for entry and model
- Fluid resembling CSF
- Puncturable third ventricle floor
- Flexible
- Cheap and disposable
- Fitted in durable skull

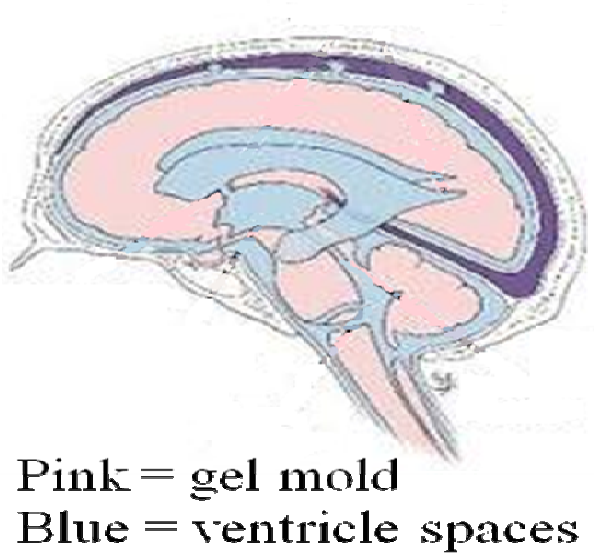


Figure 10. Injection Mold Ventricle schematic. (LifeART, 2006).

Future Work

- Produce a 3D Ventricle model in CAD
- Order hard cast of ventricle system
- Produce ballistic gel models
- Fill models with fluid
- Test model
- Refine design

Q&A

- Any questions?

References

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