Mechanical Neuro-Endoscopic Surgery Simulation Model

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Abstract

Endoscopic third ventriculostomy is performed to relieve pressure in the brain ventricles caused by blockages. It involves making an incision on the third ventricle floor to release built-up cerebrospinal fluid (CSF). A model is required to properly train medical students to ensure that medical students do not perform their first surgery on patients.

Background

- 4 Ventricles in the ventricular system
  - Secrete cerebrospinal fluid (CSF)
- 1st and 2nd lateral ventricles, drains via the intraventricular foramen to 3rd ventricle, through the cerebral aqueduct to the 4th ventricle
- Hydrocephalus is swelling of the brain due to build-up of CSF
  - Tumors, malformations, swelling
- Endoscopic third ventriculostomy relieves the pressure
- Cadavers are the current method of practice:
  - CSF drains out after death
  - Ventricles stiffen and shrink
- Existing devices are expensive
  - S.I.M.O.N.T. - $3,000

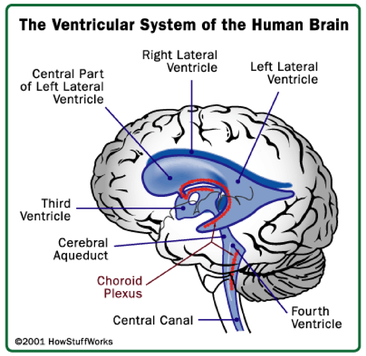


Figure 1: The human ventricular system

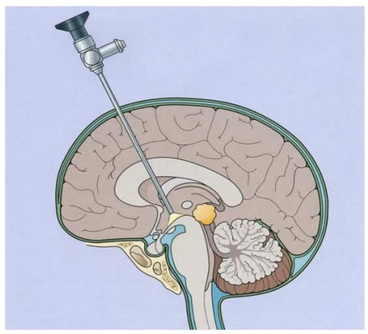


Figure 2: Endoscopic third ventriculostomy.

Design Requirements

- Simulate endoscopic third ventriculostomy
- Disposable
- Anatomically correct
- Usable with 1mm-6mm rigid endoscopes

Final Design

Our final design comprises the following:
- Solid ventricular system
- Disposable ballistics gel insert
- Durable human skull exterior
- Mineral oil

Design features:
- Similar to brain tissue texture
- Hollow ventricle spaces
- Solid ballistics gel entry point
  - Practice proper endoscope insertion
- Third ventricle floor membrane
  - Puncture to relieve pressure
- Mineral oil to resemble CSF

Creating The Model

Ventricular system
- Created out of polymer molding clay
  - Simplified: 1 lateral ventricle
- Baked at 275°F until hardened

Ballistics gel
- Gelatin powder (Knox gelatin) and water
- Mixing → hydration → melting → casting → chilling
- Removed in different components
- Components melted and remolded together again

Figure 3: Solid ventricular system

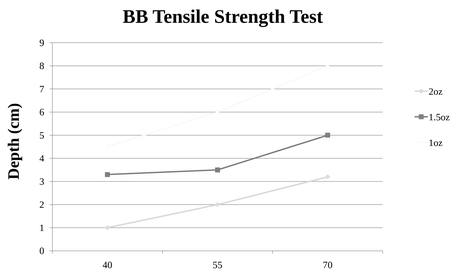
Figure 4: Removing the ballistics gel

Material Testing

- Measure ballistics gel strength
- 3 samples of different gelatin: water ratio
  - 1 oz gelatin : 1 cup water
  - 1.5 oz gelatin : 1 cup water
  - 2 oz gelatin : 1 cup water
- Fired BB gun at various temperatures:
  - 40°F
  - 55°F
  - 70°F
- Measured penetration

Table1: gel strength testing

Figure 5: BB embedded in gel



Cost Analysis

Initial cost:
- Material cost of polymer clay: $10
- Labor cost of ventricular system: $25
- Total: $35

Marginal cost (per additional model):
- Material cost of gelatin: $10
- Labor cost of preparing gelatin :$50
- Total: $60

Future Work

- Refine method of creating ventricular system and ballistics gel model
- Refine design based on client feedback
- Connect video simulation of actual surgery

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