An Investigation of Diagnostic and Treatment Methods for Patients Suffering from Arachnoid Cysts

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Hydrocephalus Overview

Hydrocephalus is a chronic medical condition that affects over a million people in the US every year. It is characterized by an abnormal accumulation of cerebrospinal fluid (CSF) in the brain, which can lead to increased intracranial pressure and potential complications like headaches, nausea, and vision issues.

There is no known cure.

Hydrocephalus Symptoms

- Headaches
- Nausea
- Vision issues
- Altered mental status
- Motor skills impairment
- Death if left untreated

Causes of Hydrocephalus

- Hydrocephalus can be either congenital or acquired.
- There are two main causes of hydrocephalus:
  1. Non-Communicating (caused by obstruction):
     - Lesions such as arachnoid cysts, tumors, or hematomas
  2. Communicating (caused by absorption issues):
     - Related to venous sinus
     - Inflammation from infections such as meningitis, or swelling from injury

Prevalence of Hydrocephalus

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Arachnoid Cysts

- Non-Communicating Cysts can cause hydrocephalus.
  - Arachnoid cysts may be in size and can be communicating or non-communicating.
- Both communicating and non-communicating cysts press on neural structures, leading to symptoms like headaches, nausea, vision issues, motor skills impairment, and other neurological complications.

The Occurrence of Arachnoid Cysts

- Arachnoid cysts are commonly reported to occur in approximately 1% of the population.
- Although rare, these cysts are the most common cause of hydrocephalus.
- Both communicating and non-communicating cysts can contribute to hydrocephalus.
- More arachnoid cysts are congenital and likely arise from the anomalous splitting of the arachnoidal plate over time.
- Many cysts are asymptomatic and identified incidentally on neuroimaging.
- Given the difficulty in diagnosing whether symptoms are caused by cysts or another brain disorder, clinicians are often unsure as to whether or not cysts should be treated.

Given modern imaging techniques, a radiology study would yield valuable information regarding the occurrence, size, and location of arachnoid cysts.

Flow chart tracing published articles containing the 1% statistic back to the original source, Robinson 1971

The Complexity of Modeling the Subarachnoid Space

- The complexity of modeling the subarachnoid space is due to the high degree of variability in the shape and size of the subarachnoid space. This variability can affect the flow dynamics and pressure distribution in the space.

The Occurrence of Arachnoid Cysts

- Arachnoid cysts are commonly reported to occur in the population.

Subarachnoid Space Modeling

- Most head models were developed to study traumatic brain injury (TBI) or CSF flow patterns through the head.
- While head models can provide valuable insights into the subarachnoid space, they do not accurately model the local and global effects of arachnoid cyst obstruction, which is a more detailed model of the subarachnoid space in regard to various geometries and flow configurations.

Biomechanical Material Models

- Material properties play a crucial role in the behavior of the subarachnoid space. The properties of the materials in the subarachnoid space determine the flow dynamics and pressure distribution.

Research Conclusions

1. The occurrence of arachnoid cysts in the population should be determined using modern imaging on a large sample size.
2. Improved models and methodology are essential to determine the effects of arachnoid cysts on local and global pressure for accurate diagnosis of symptoms.
3. Head models must include a detailed representation of the subarachnoid space to capture effects of increased local pressure on surrounding neural structures and possible effects of this obstruction on global pressure and CSF flow.
4. The optimized design of shunts should include the effects of fluid structure interaction and account for the probabilistic nature of the input parameters.