Hydrocephalus etiology

- Mutation of beta-tubulin 4B gene (TUBB4B) causes autosomal dominant retinitis pigmentosa with sensorineural hearing loss in a multigenerational family
- Transcriptomic and histological characteristics of innate immune activation in brain parenchyma in a rat model of neonatal intraventricular hemorrhage
- Comparative analysis of lumbar cerebrospinal fluid drainage versus lumbar puncture effectiveness in patients with aneurysmal subarachnoid hemorrhage
- Genetic etiology of ventriculomegaly in 73 fetuses identified by High-Throughput sequencing
- The Hydrocephalus Association Patient-Powered Interactive Engagement Registry (HAPPIER): Design and Initial Baseline Report
- Multicenter study on etiological characteristics of bacterial meningitis in infants aged < 90 days
- Microsurgical pineal cyst fenestration: A safe and effective treatment strategy in patients with symptomatic pineal cyst syndrome
- Spina Bifida

The **etiology of hydrocephalus** refers to the underlying causes of the condition, which can vary widely depending on whether it is congenital or acquired. Hydrocephalus is typically characterized by the abnormal accumulation of cerebrospinal fluid (CSF) within the ventricles of the brain, leading to increased intracranial pressure. This condition can result from several different causes, and understanding its etiology is crucial for diagnosis, treatment, and prevention.

1. **Congenital Hydrocephalus**

2. **Acquired Hydrocephalus** Acquired hydrocephalus develops after birth, often due to head injury, infection, or other neurological conditions that affect the normal flow of CSF. Common causes of acquired hydrocephalus include:

a. **Traumatic Brain Injury (TBI)**

1. **Cause**: Head injuries, such as a concussion or skull fracture, can cause bleeding or swelling in the brain, obstructing the flow of CSF and leading to hydrocephalus. This condition is known as post-traumatic hydrocephalus.
2. **Pathophysiology**: The blood from a traumatic injury may clog or scar the normal CSF pathways, causing CSF to accumulate in the ventricles.

b. **Infections**

1. **Cause**: Meningitis (inflammation of the protective membranes around the brain and spinal cord) is a leading cause of acquired hydrocephalus, particularly when the infection leads to scarring or obstruction of the ventricles or the subarachnoid space.
2. **Other infections**: Encephalitis or viral infections can also cause inflammation and damage that may result in hydrocephalus.

c. **Brain Tumors**

1. **Cause**: Tumors, whether benign or malignant, can block the normal flow of CSF by compressing or obstructing the ventricles or the pathways through which CSF circulates.
2. **Types**: Gliomas, medulloblastomas, or metastatic tumors are common causes of obstructive hydrocephalus. Tumors can also cause hydrocephalus by obstructing the arachnoid villi, which

are responsible for CSF absorption.

d. **Subarachnoid Hemorrhage (SAH)**

1. **Cause**: Bleeding into the subarachnoid space, typically from a ruptured aneurysm, can disrupt the normal reabsorption of CSF, leading to hydrocephalus. This is often referred to as **communicating hydrocephalus**.
2. **Pathophysiology**: The blood blocks the reabsorption of CSF, resulting in fluid accumulation.

e. **Hydrocephalus Ex-Vacuo**

1. **Cause**: This type of hydrocephalus is often seen in neurodegenerative diseases, such as Alzheimer's disease or after a stroke. It occurs due to the loss of brain tissue, which creates empty spaces that fill with CSF.
2. **Pathophysiology**: The brain shrinks in volume, and the CSF spaces enlarge to compensate, but there is no obstruction in the CSF pathways.

f. **Normal Pressure Hydrocephalus (NPH)**

1. **Cause**: NPH is a condition typically seen in older adults, where CSF accumulates without significantly increased pressure. It is often associated with aging or prior brain injury, though its exact cause remains unclear.
2. **Symptoms**: The condition presents with a classic triad of symptoms: gait disturbance, urinary incontinence, and cognitive decline.

3. **Genetic and Syndromic Causes** Some genetic conditions are associated with an increased risk of developing hydrocephalus, often due to abnormalities in the CSF circulation system. Common syndromic causes include:

- **X-linked hydrocephalus**: A genetic disorder linked to mutations in the L1CAM gene, leading to obstructive hydrocephalus. - **Dandy-Walker Syndrome**: A congenital malformation involving the cerebellum and the fourth ventricle, often leading to hydrocephalus. - **Apert Syndrome** and other craniofacial syndromes: These can be associated with abnormal development of the skull and brain, resulting in hydrocephalus.

4. **Obstruction of CSF Circulation** Hydrocephalus can occur when there is physical obstruction to the flow of CSF. Common causes of CSF obstruction include:

- **Congenital defects**, such as aqueductal stenosis or Chiari malformations. - **Acquired obstructions**, such as brain tumors, cysts, or scar tissue from infection or injury.

Conclusion: The etiology of hydrocephalus is multifactorial, involving a combination of genetic, developmental, environmental, traumatic, and pathological factors. Understanding the underlying cause of hydrocephalus is critical for determining the most appropriate treatment and management strategies, as different causes may require different interventions. Advances in neuroimaging, genetic research, and the development of improved surgical techniques are continuously enhancing our ability to diagnose and treat hydrocephalus more effectively.

A range of neurological pathologies may lead to secondary hydrocephalus.

see Pediatric Hydrocephalus Etiology

Acquired

a) infectious (the most common cause of communicating HCP)

● post-meningitis; especially purulent and basal, including TB, cryptococcus

● cysticercosis

b) post-hemorrhagic (2nd most common cause of communicating HCP)

● post-SAH

● post-intraventricular hemorrhage (IVH): many will develop transient HCP. 20–50% of patients with large IVH develop permanent HCP, requiring a shunt

Congenital (without myelomeningocele) 38%

Congenital (with myelomeningocele) 29%

Perinatal hemorrhage 11%

Traumatic subarachnoid hemorrhage 4.7%

Tumor 11%

Previous infection 7.6%

c) secondary to masses

● non neoplastic: e.g. vascular malformation

● neoplastic: most produce obstructive hydrocephalus by blocking CSF pathways, especially tumors around aqueduct (e.g. medulloblastoma). A colloid cyst can block CSF flow at the foramen of Monro.

Pituitary tumor: suprasellar extension of tumor or expansion from pituitary apoplexy

d) post-op: 20% of pediatric patients develop permanent hydrocephalus (requiring shunt) following p-fossa tumor removal. May be delayed up to 1 yr

e) neurosarcoidosis

f) “constitutional ventriculomegaly”: asymptomatic. Needs no treatment

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Hydrocephalus has many causes:

Postinfectious hydrocephalus.

Postoperative hydrocephalus.

Posttraumatic hydrocephalus.

Posthemorrhagic hydrocephalus.

Trapped fourth ventricle.

Neurofibromatosis type 1 related hydrocephalus

Congenital hydrocephalus, most commonly involving aqueductal stenosis, has been linked to genes that regulate brain growth and development.

Newborn infants with germinal matrix hemorrhage.

Hydrocephalus can also be acquired, mostly from pathological processes that affect ventricular outflow, subarachnoid space function, or cerebral venous compliance.

Spontaneous subarachnoid hemorrhage/Aneurysmal subarachnoid hemorrhage.

Meningitis

Hydrocephalus after decompressive craniectomy.

Terminal deletion of chromosome 6q is a rare chromosomal abnormality associated with intellectual disabilities and various structural brain abnormalities.

Iwamoto et al. presented a case of 6q terminal deletion syndrome with unusual magnetic resonance imaging (MRI) findings in a neonate.

The neonate, who was prenatally diagnosed with dilation of both lateral ventricles, was born at 38 weeks of gestation. MRI demonstrated an abnormal membranous structure continuing to the hypertrophic massa intermedia in the third ventricle that had obscured the cerebrospinal fluid pathway, causing hydrocephalus. G-band analysis revealed a terminal deletion of 6q with the karyotype 46, XY, add(6)(q25.3) or del(6)(q26). He underwent ventriculoperitoneal shunt successfully, and his head circumference has been stable.

6q terminal deletion impacts the molecular pathway, which is an essential intracellular signaling cascade inducing neurological proliferation, migration, and differentiation during neuronal development. In patients with hydrocephalus in association with hypertrophy of the massa intermedia, this chromosomal abnormality should be taken into consideration. This case may offer an insight into the hydrocephalus etiology in this rare chromosomal abnormality [1)].

Hydrocephalus after intraventricular hemorrhage

Hydrocephalus after intraventricular hemorrhage

Posttraumatic hydrocephalus

Posttraumatic hydrocephalus

Hydrocephalus after Vertebrobasilar Dolichoectasia

Hydrocephalus after Vertebrobasilar Dolichoectasia.

Myelomeningocele-associated hydrocephalus

Myelomeningocele-associated hydrocephalus.

Intracerebral hemorrhage

see Intracerebral hemorrhage complications

Hydrocephalus due to spinal tumor

Hydrocephalus due to spinal tumor

[1)]

Iwamoto H, Muroi A, Sekine T, Tsurubuchi T, Ishikawa E, Matsumura A. Unusual Form of Obstructive Hydrocephalus in Association with 6q Terminal Deletion Syndrome: A Case Report and Literature Review. Pediatr Neurosurg. 2019 Oct 9:1-5. doi: 10.1159/000503108. [Epub ahead of print] PubMed PMID: 31597145.