



# Chapter-04

## HYDROCEPHALUS AND ITS MANAGEMENT

**Shashank Pal\***

*Tutor, Glocal College of Paramedical Science and  
Research Centre, Glocal University, Saharanpur, U.P., India.*

**Gurdeep Panwar**

*Assistant Professor, Glocal College of Paramedical Science and  
Research Centre, Glocal University, Saharanpur, U.P., India.*

**Mohd Shahid Bhat**

*Tutor, Glocal College of Paramedical Science and  
Research Centre, Glocal University, Saharanpur, U.P., India.*

*\*Correspondence to: [shashank.pal@theglobaluniversity.in](mailto:shashank.pal@theglobaluniversity.in)*

**DOI: <https://doi.org/10.52458/9789388996846.nsp2023.eb.ch-04>**  
**Ch.Id:-GU/NSP/EB/CMDT/2023/Ch-04**

## **ABSTRACT**

*Hydrocephalus is a neurological disorder defined as abnormal collection of cerebrospinal fluid (CSF) within the brain's ventricles, leading to increased intracranial pressure and potentially damaging consequences. This chapter provides a comprehensive overview of hydrocephalus, encompassing its etiology, clinical manifestations, diagnostic methods, and treatment options. Additionally, it explores the diverse causes of hydrocephalus, including congenital, acquired, and idiopathic forms, highlighting the importance of early diagnosis and intervention. The chapter delves into the various surgical and non-surgical management approaches, emphasizing the importance of individualized treatment plans to optimize patient outcomes.*

**Keyword:** *Cerebrospinal Fluid, Ventricles, Hydrocephalus, Neurology, Shunts, Physiotherapy, Pathology.*

## **4.1 INTRODUCTION**

Hydrocephalus, a term originating from Greek meaning 'Water head,' refers to an abnormal a collection of cerebrospinal fluid (CSF) in the brain's ventricles and/or subarachnoid spaces, resulting in increased intracranial pressure.

This disorder, characterized by CSF build up in brain ventricles, affects both infants and elderly adults. Hydrocephalus can be classified into two types: communicating and non-communicating.

Excessive CSF accumulation in the brain's ventricles defines hydrocephalus, a central nervous system disorder. It can present at any age group and leads to significant cognitive and physical impairment. Various conditions like brain tumours, strokes, infections, and haemorrhage can cause hydrocephalus (Krishnamurthy, et al., 2014).

The understanding of hydrocephalus dates back centuries, with Hippocrates and Claudius Galen recognizing fluid accumulation in the head. Contributions from Thomas Willis, Franciscus Sylvius, Alexander Monroe, and Francois Magendie furthered our knowledge of cerebrospinal fluid pathways (Venkataramana, et al.,2011)

Hydrocephalus is the characteristic by accumulation of CSF in cerebral ventricles, which can result from various causes, including obstruction, absorption issues, or excessive production.

The primary treatment for hydrocephalus involves surgical intervention, such as ventricular shunt placement or endoscopic third ventriculostomy (ETV) and choroid plexus cauterization for suitable cases. Without prompt treatment, acute hydrocephalus

can lead to brain herniation and death, with a fatality death rate in children ranging from 0 to 3%, depending on follow-up duration (Koleva, et al.,2022).

## **4.2 FUNCTION**

CSF plays a vital role in supporting the brain by offering protection, nourishment, and waste removal. It achieved this through two key mechanisms. Firstly, CSF functions as a shock absorber, safeguarding the brain against impacts with the skull. Secondly, it allows the brain and spinal cord to float, significantly reducing the effective weight of the brain from its usual 1,500 grams to a mere 50 grams.

CSF also plays a relation in eliminating waste products generated by brain metabolism, such as peroxidation byproducts, glycosylated proteins, excess neurotransmitters, debris from the ventricular lining, bacteria, viruses, and other unnecessary molecules (Telano, et al.,2022).

## **4.3 MECHANISM**

### *CSF CIRCULATION*

Cerebrospinal Fluid (CSF): Structure and Functions\*

- 1. Production and Circulation-** CSF is a transparent fluid, derived from plasma ultra-filtrate. It's found in the intracranial and spinal compartments. Produced continuously by the choroid plexus in brain ventricles. circulates in the subarachnoid space of the brain and spinal cord. Adult CSF volume is around 140 ml. Production rate: 0.2–0.7 mL per minute or 500–700 mL per day.
- 2. Main Functions -** Reduces brain buoyancy and protects it. Supplies nutrients and removes substances like amino acids and waste products.
- 3. Homeostasis -** balance stable CNS temperature. regulates osmotic pressure and cerebral perfusion. Clears waste through resorption and lymphatic drainage.
- 4. Nutrition -**Contains glucose, proteins, lipids, and electrolytes, providing CNS nutrition.
- 5. Support and Protection -** Supports the brain's weight (1500 gm) in neutral buoyancy. Acts as a shock absorber, preventing brain damage during trauma (Krishnamurthy, et al.,2014).

#### **4.4 CLINICAL SIGNIFICANCE**

- **Lumbar puncture and CSF Analysis:** Lumbar puncture is a sterile procedure, done to obtain cerebrospinal fluid samples for diagnostic purposes. It involves passing a needle into the subarachnoid space at the levels between L2 and L5 vertebrae. However, most commonly lumbar puncture is performed between L4 and L5.:

Normal CSF parameter.

Color: clear or colorless

CSF Pressure: 8 mmHg to 15 mmHg

Glucose: 50 mg/dl to 80 mg/dl or two-thirds of blood glucose level

Protein: 15 mg/dl to 45 mg/dl

Mononuclear cells: 0 to 5/mm<sup>3</sup>

- **CSF Formation:** The primary source of cerebrospinal fluid production is believed to be the choroid plexuses, contributing to about 70-80% of CSF production. This process involves filtration across capillary walls and secretion through choroidal epithelium. The rest of the 20-30% of cerebrospinal fluid production is thought to arise as bulk flow from interstitial fluid, likely produced by the ependyma.
- **CSF Circulation:** CSF flow is attributed to the pulsatile flowing action of the choroid plexuses, generated by the accumulate and passes of these structures
- **CSF Absorption:** Arachnoid villi situated within the dural venous sinuses are traditionally regarded as the primary site for CSF absorption. It's believed that CSF absorbed from the cranial sub valvular aortic stenosis to the cranial venous blood through a hydrostatic gradient.
- **Hydrocephalus and Blockage:** In line with circulation theory, hydrocephalus occurs when there is an imbalance between cerebrospinal fluid production and absorption. Any condition that obstructs the normal flow of CSF or its absorption can lead to hydrocephalus (Krishnamurthy, et al.,2014).

#### **4.5 ETIOLOGY**

Hydrocephalus refers to an excess of cerebrospinal fluid, which typically occurs in conditions involving diffuse brain atrophy such as cerebral arteriosclerosis, general paresis, and presenile dementias. In these cases, hydrocephalus is compensatory and

lacks clinical significance. Symptoms of hydrocephalus arise when cerebrospinal fluid exerts increased pressure.

**Hydrocephalus with congenital origin:** Congenital hydrocephalus typically arises from inherent structural anomalies that disrupt the normal cerebrospinal fluid circulation at multiple points. It can sometimes coincide with spina bifida. The cerebral aqueduct may exhibit narrowing or absence, or an Arnold-Chiari malformation may be present, where a area of the cerebellum extends into the foramen magnum, causing an impediment in the outflow from the fourth ventricle. This irregularity is often linked to syringomyelia and lumbosacral spina bifida.

**Acquired Obstructive Hydrocephalus:** Acquired hydrocephalus can develop when a tumor forms in the third or fourth ventricle, or within the midbrain, where the cerebral aqueduct may become narrowed due to ependymitis. Additionally, adhesions that develop following meningitis or arachnoiditis can block the outflow from the 4th ventricle or close off the cerebrospinal channels in the cisterns above the tentorium. Parasitic cysts can also lead to obstruction at any of these sites. Thrombosis of the superior sagittal sinus can hinder the absorption of CSF. When this condition is a result of otitis, it is referred to as otitis hydrocephalus (Tidy, et.al.,2016).

## **4.6 CLASSIFICATION**

Hydrocephalus, marked by production increased CSF capacity and cerebral ventricle dilation, encompasses various types:

### **1. Obstructive Hydrocephalus**

- a. Congenital malformations, post inflammatory or posthemorrhagic causes, Mass lesions

### **2. Communicating Hydrocephalus**

- b. Overproduction of CSF, Defective CSF absorption, Venous drainage insufficiency

### **3. Normal Pressure Hydrocephalus**

### **4. Hydrocephalus ex Vacuo (Curt, et.al.,2014)**

## **4.7 CLINICAL FEATURES**

Gait abnormalities, lack sense of instability, vertigo, motion illusions, lightheadedness, or muscle weakness Gait apraxia shuffling gait dysarthria nystagmus slight slowing of their walking pace, and a subtle sense of instability, cognitive deficits,

bladder control disturbance, aphasia, dementia slowing of mental processing, a reduction in organizational and problem-solving skills, urinary incontinence (Karimzadeh, et.al.,2014).

#### **4.8 DIAGNOSIS**

**PHYSICAL EXAMINATION-** the physical examination should encompass various aspects, including checking vital signs, conducting a mental status assessment, observing behaviour, evaluating cranial nerves (including a fundoscopic examination), assessing speech and language, conducting motor and sensory tests, testing reflexes, and examining gait. (Rowland, et.al.2020).

#### **4.9 EVALUATION**

Cerebrospinal fluid analysis can be a valuable diagnostic tool, helping to confirm the diagnosis and rule out any residual infections.

X-rays of the skull might reveal erosion of the sella turcica or the “beaten copper cranium” appearance, but they are rarely used today due to the availability of more advanced imaging techniques.

Neuroimaging plays a vital crucial relation in confirming diagnoses, identifying underlying causes, and determining potential treatment options. In cases of acute hydrocephalus, an emergency head computed tomographic (CT) scan is typically the initial choice for assessing ventricular size (Telano, et.al.,2022).

#### **4.10 MANAGEMENT - MEDICAL MANAGEMENT**

1. **Medical Interventions:** In certain situations, medical interventions can be considered. Osmotic diuretics and acetazolamide, which suppress carbonic anhydrase, have been employed.
2. **Shunt Procedure:** Shunt procedures have become the cornerstone of surgical treatment for hydrocephalus, even in severe cases.
3. **Components of Shunt Assembly:** A typical shunt assembly consists of a proximal catheter placed within the cerebral ventricles, a distal catheter leading to a chosen site for CSF absorption, and a valve and reservoir integrated into the shunt system.
4. **Valve Types:** Shunt valve designs are based on differential pressures and can be either fixed or programmable.
5. Pressure Gradient and Anti-Siphon Device.

6. **Distal Catheter Placement:** The distal end of the catheter can be placed in various locations, including the right atrium, pleural cavity, and gall bladder. However, the most common area for distal catheter placement is the peritoneal cavity (Venkataramana, et, al.2011).
7. **Surgical Management** - In cases of obstructive or non-communicating hydrocephalus, the primary goal is to alleviate the blockage causing the condition. Surgical removal of the obstruction is typically the preferred approach (Groat, et.al.,2013).

#### **4.11 VENTRICULOPERITONEAL SHUNTING**

1. **Ventriculoperitoneal Shunt (VP):** This is the most important method for diverting cerebrospinal fluid (CSF). It relies on the abdomen's capacity to absorb the fluid. VP shunts establish unidirectional CSF flow controlled by a valve system.
2. **Ventriculoarterial Shunting:** This procedure is typically chosen for patients who cannot accommodate abdominal distal catheters. However, it comes with higher risks and the potential for severe long-term complications such as renal failure or vein thrombosis. The procedure involves making an incision along the anterior border of the sternocleidomastoid muscle to access the jugular vein.
3. **Endoscopic Third Ventriculostomy (ETV):** ETV serves as an alternative therapy to CSF shunting in specific cases. It is a minimally invasive surgical management approach applicable to patients with conditions like by birth aqueduct stenosis or intracranial cysts causing local CSF accumulation. The primary goal of ETV is to create an opening in the floor of the 3rd ventricle leading to the subarachnoid space (Groat, et.al.,2013).

#### **4.12 PHYSIOTHERAPY MANAGEMENT**

Physiotherapy plays a significant role in the comprehensive management of hydrocephalus, especially when initiated early. Its primary focus is to enhance the child's functional abilities and minimize impairments associated with the condition. the physiotherapist conducts a thorough assessment of the child's mobility, taking into account gross motor skills like crawling and limb flexibility, which can often be affected.

**Physiotherapy interventions encompass various aspects:**

1. **Gait and Mobility:** Physiotherapists provide guidance on walking and gait patterns to improve leg coordination and overall movement.

2. **Activities and Participation:** Therapists assist the child in various activities, making them enjoyable to encourage participation and enhance functional skills.
3. **Therapeutic Exercises:** Exercises are incorporated into therapy sessions to prevent muscle weakness, maintain muscle mass, stretch tight muscles, and strengthen weak ones. These exercises also contribute to better balance.
4. **Developmental Milestones:** Physiotherapists offer guidance to achieve developmental milestones, such as independent sitting and crawling.
5. **Neck and Trunk Control Information** is provided to support the development of neck and trunk control, crucial for maintaining posture and movement (Hrishi, et.al., 2019).

#### **4.13 CONCLUSION**

In simple terms, hydrocephalus is a medical condition characterized by an excessive accumulation of fluid within the brain, resulting in increased tension and a range of associated issues. Timely diagnosis and suitable treatment, which may include surgical intervention, are crucial in managing this condition and improving the feature of life for those affected. It's essential for individuals with hydrocephalus to work closely with team of healthcare professionals to receive tailored care and help throughout their journey with this condition.

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