A Literature review on Pediatric hydrocephalus: co-morbidities and environmental factors as a common denominator

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Abstract:

Hydrocephalus is an active distension of the ventricular system of the brain resulting from the inadequate passage of CSF from its point of production within the cerebral ventricles to its point of absorption into the systemic circulation. The role of diuretic therapy in the management of hydrocephalus in children. The study's objective is to create awareness among women in the gestational period about the causes, symptoms, and supportive treatments of hydrocephalus. Pediatric age groups with the denouement of hydrocephalus have been focused to test the efficacy of supportive therapy for HC patients. This study was conducted to assess the effectiveness of supportive therapy in treating the condition. Patients who meet the study's eligibility requirements will be included in the study. Within six months, a thorough follow-up should be conducted through interviews conducted during their reviews or phone calls. Since pediatric hydrocephalus is a condition that often affects children living in poverty and poses a socioeconomic barrier due to delayed shunt procedures designed to lengthen patient lifespans.

KEYWORDS: HC, SUPPORTIVE THERAPY, CSF, PEDIATRIC, HEAD SIZE, LIFE SPAN.

Introduction

Across all vertebrate animals, as well as the majority of invertebrate ones, the brain continues to serve as the hub of the nervous system. It is situated within the head, typically close to the sensory structures that support senses like vision. This is the most intricate organ that is part of a vertebrate. The human brain seems to be the nervous system's command center, enabling ideas, and processing of thoughts and feelings, as well as memory, involved with movement, and emotions through a complex function that represents the highest outcome of evolutionary processes and biological responses (Eccles, 1973) The ultimate objective and goal are pursuing longevity and well-being is to keep a strong brain throughout one's life. As the population ages, the burden of neurological disorders and the challenges of maintaining brain health grow. In all vertebrate and most invertebrate animals, the brain serves as the center of the nervous system. The forebrain is the largest region in the brain, which is further divided into the cerebral hemispheres, the corpus callosum, the thalamus, the hypothalamus, and the hippocampus. The cerebellum, pons, and medulla are located beneath the forebrain in the hindbrain (Cowan, 1979). Hydrocephalus is defined as active distension of the brain's ventricular system caused by insufficient CSF passage from its point of production within the cerebral ventricles to its point of absorption into the systemic circulation.

Hydrocephalus is a common disorder caused by an abnormal accumulation of cerebral spinal fluid (CSF) in the brain. It thus appears to be the result of a wide range of factors that can affect a fetus, newborn, child, or elderly. There are a few definitions of hydrocephalus. (Dominic Thompson MB, 2005). The physiology that causes abnormal ventricle development. Hydrocephalus could be congenital, tends to result from such a disruption in the development of the CSF pathways, or is acquired as an outcome of secondary events that inhibit circulation channels. Hydrocephalus is an illness in which an oversupply of cerebrospinal fluid (CSF) builds inside this brain's ventricular system and cisterns, resulting in increased intracranial pressure (ICP) and other complications. (Tripathi, (1974)) To summarize, there's a noticeable imbalance between both CSF production and absorption. Overproduction of CSF can also be caused by choroid plexus tumors; however, these are uncommon in clinical practice.

History

In ancient times, hydrocephalus was recognized. (Aschoff, 1999) Hippocrates (BC 460-377) and Claudius Galen both acknowledged vasodilation in numerous intracranial compartments (130–200 AD). Thomas Willis’ (1621-1675) research aided the comprehension of the ventricular system and CSF pathways. Francisculus Sylvius (1614-1672), Alexander Monroe (1733-1817), and Francois Magendie (1783-1855) all contributed significantly to the anatomy of the CSF pathway. Eventually, the modern concept of CSF circulation was established by Key and Retzeus (1876). The diagnosis and management were unclear at the time, resulting in a high mortality rate.

(Blitz, 2018) Dandy and Black Fan (1913) made additional contributions by developing experimental methods of hydrocephalus that resulted in the classification as well as divergence of non-communicating (obstructive) and communicating forms with distinct therapeutic options.
The treatments available included choroid plexus removal, removal of obstructive pathologies, and the creation of conduits to drain CSF from the intracranial compartment. John Scarff characterized the history of hydrocephalus diagnosis in in-depth information in 1963. (Dandy, 1913) In 1922, Walter Dandy suggested a third ventriculostomy for an obstructive wide range. Torkildson procedure, which happens to involve draining the lateral ventricle into the cisterna magna, as well as ventriculosisternostomy throughout cases of aqueduct obstruction, are two of these surgical procedures. Until 1939, there has been a flood of operative techniques for CSF diversion. Synthetic, biologically tolerant polymers, particularly silicone elastomers, became available in the 1950s, ushering in an era of shunts. In the meantime, advances in optics and endoscopes were repolarized. as per Mixter’s initial endoscopic 3rd ventriculostomy.

Embryology

The ventricular system develops from the neural tube's corresponding vesicles. So, every telencephalic vesicle's cavity has now become the lateral ventricle, as well as the diencephalic vesicle's cavity becomes the third ventricle. The fourth ventricle is formed by the cavity of the rhombencephalon. (Marvin D. Nelson) The central canal has been continuing into the spinal cord. Thus, every lateral ventricle is a spherical space within the telencephalic vesicle all through development. The ventricle grows Antero posteriorly as it grows forward as well as backward. The telencephalic vesicle's posterior end now tends to grow downward and forward to establish the chronological horns, giving the ventricles a "C" shape. Finally, the occipital horns recede. The convergence of the two emerging telencephalic vesicles causes these same medial walls of the lateral ventricles to collide, forming a septum. (Hamilton, 1945) Well, this surface develops into the third ventricle's roof, as well as its lateral invagination creates a choroidal fissure. The tela choroidea is created by the extension of a pia mater fold into this fissure. Here in this fold, a collection of capillaries grows, creating a choroid plexus. (Winn) (Tripathi, (1974))

Cerebrospinal fluid production and absorption

A whopping 70–80% of the daily volume of CSF is produced by the choroid plexus. Both brain parenchyma and ventricular ependyma have a comparatively tiny ability to generate CSF. The production of CSF involves both filtration across the endothelium and active sodium transport by the choroidal epithelia. The production of CSF involves both filtration across the endothelium and active sodium transport by the choroidal epithelia. The production of CSF involves both filtration across the endothelium and active sodium transport by the choroidal epithelia. (Bradley, 2015)

To create a subarachnoid space, the CSF separates and divides into meninx primitive's intercellular space. The parasagittal arachnoid granulations are reached by the CSF from the subarachnoid space. (Weed, 1914)

A lot of research has been done on the CSF absorption mechanisms. There's been speculation regarding direct absorption from the cribriform plate region's lymphatic channels, choroid plexus, or brain parenchyma. The absorption edge is aided by the arachnoid villi and granulations. Arachnoid tissue that has herniated further into the Dural venous sinuses seems to be what causes the villi. There have been suggested two mechanisms. (Simon, 2016) The "closed" mechanism occurs when there is blind diverticulitis of the villi and seepage across the endothelial layer to achieve absorption. The open mechanism shows that there are channels across villi that allow for both the unidirectional flow of CSF and can be opened or closed in a valve-like fashion. Vacuoles that carry CSF across the endothelial layer try to compensate as much as possible for Tripathi's proposed transmembrane transport mechanism. The CNS microcirculation's role in CSF absorption has recently advanced our understanding of the pathogenesis of hydrocephalus. We are compelled to adhere to our understanding and classification based on conventional principles of CSF circulation since these mechanisms are indeed unclear. (Tripathi, (1974))

Classification

The precise site of CSF flow obstruction can be determined using the results of modern CT and magnetic resonance imaging (MRI) techniques. Consequently, the following classification is more accurate: One of three things can lead to hydrocephalus:

1) an excessive amount of CSF is produced (a rare condition).

2) lateral ventricles and foramen of Monroe, aqueduct of Sylvius, third and fourth ventricle, or subarachnoid spaces are blocked from CSF flow.

3) defect in the absorption.

One type of hydrocephalus is mono ventricular or unilateral, another is biventricular (both lateral ventricles), a third type is a tri ventricular (third lateral ventricles), and a fourth type is panned ventricular (4th, 3rd, and both lateral ventricles).

(Baumann, 1978) A secondary classification under one of the following headings may be added, depending on the precise etiology: Neoplastic, traumatic, degenerative, congenital, inflammatory, and five other types of hydrocephalus.
Hydrocephalus is managed to bring on by a buildup of fluid inside the ventricles, which are deep inside the brain. The extra fluid causes the ventricles to enlarge, which increases the amount of pressure in the brain. (M Van Landingham, 2008) Typically, cerebral spinal fluid bathes the spinal column in the brain by passing through into the ventricles. Nevertheless, the pressure of too much cerebrospinal fluid associated with hydrocephalus may damage brain tissues and result in a variety of cognitive function issues.

Although hydrocephalus can appear at any age, it is more frequent in infants and people 60 years and older. Since its inception, doctors have been fascinated by hydrocephaly due to its horrifying appearance. (A Aschoff, 1999) Hippocrates had already advocated depressurization as a hydrocephalus treatment. Procedures that provide more effective treatment will have to be created once the anatomy and pathophysiology of hydrocephalus, as well as the production and absorption of cerebrospinal fluid, have been clarified.

In addition, there are obstructive and non-obstructive subtypes of hydrocephalus. (Koleva & Jesus, 2023) It is known that either a CSF flow obstruction or a decrease in the body's capacity to store CSF can lead to hydrocephalus. Pressures inside the brain are then risen by swelling brought on by CSF buildup inside the ventricles and subarachnoid spaces. Despite the likelihood of intracranial hypertension in children over the age of two, infants frequently develop progressive macrocephaly. (Kahle, 2016) Traditional methods that incorporate abnormal cerebral pulsations, brain compliance, and unique, fully categorized water-transport mechanisms are replacing the conventional theory of hydrocephalus as the outcome of a blockage inside the bulk flow of CSF.

There are several causes of hydrocephalus, which develop when the balance between CSF production and absorption is upset, leading to dilated ventricles. There seem to be numerous classifications, (Oi, 2006) but the two most used are obstructive (non-communicating) and communicating. The obstructive pathway manifests as a block in cerebrospinal fluid (CSF) proximal to arachnoid granulation, whereas the direct pathway method manifests as an abnormality in uptake at arachnoid granulation.

**SIGNS AND SYMPTOMS EXPERIENCED BY A HYDROCEPHALUS INDIVIDUAL:**

- Depending on one's age, the stage of the disease, and their level of acceptance of the situation, each person's hydrocephalus will manifest differently clinically.
  - Adults may experience loss of function, such as difficulty walking or thinking, whereas infants and young children may be more susceptible to the symptoms of increased intracranial pressure, such as vomiting. An infant's ability to make up for increased CSF pressure and ventricle enlargement differs from an adult. The infant skull may indeed enlarge to facilitate the accumulation of CSF because the sutures, the fibrous joints connecting the bones of the skull, have not yet been forced to close. (Kirkpatrick, 1989)

**Infants/Neonates:**
- scalp veins
- Downward deviation of the eyes (also called “sunsetting”)
- Vomiting
- Irritability
- Sleepiness
- Seizures
- Rapidly increasing head circumference

**Children:**
Adults and older children may exhibit different symptoms because of their skulls' limitations in accommodating CSF buildup.

**Possible symptoms they experience are as follows:**
- Blurred or double vision,
- Lethargy,
- Nausea,
- Headache,
- Sun setting of the eyes,
- Problems with balance walking,
- Poor coordination,
- Vomiting,
- Drowsiness.

**RISK FACTORS:**
- The most typical hydrocephalus risk factors include: (Munch, 2014) (Van Landingham, 2009) (Romero, 2015)
  - Lack of prenatal care,
An abnormal buildup of cerebrospinal fluid in the cerebral ventricles is known as hydrocephalus, and it is typically brought on by a problem with the fluid’s bloodstream absorption. In other words, When CSF cannot adequately travel out of its point of production inside the cerebral ventricles towards its point of absorption to the systemic circulation, it causes hydrocephalus, an active distension of the brain’s ventricular system. Although patients with this disorder have a less-than-ideal prognosis, the pathophysiology of congenital and neonatal hydrocephalus is not well understood. This could be because the injury mechanisms are numerous and overlap with epidemiology, which is also complex and varied. (McAllister II, 2012)

Mechanical, ischemic, and metabolic-toxic disturbances act just like their main mediators. (Del Bigio, 2001) iNPH appears to combine several pathogenetic elements, creating a vicious cycle that reinforces itself. Most studies suggest CSF disturbances due to altered hemodynamics. (Bräutigam, 2019) Vascular, hemodynamic, and metabolic factors are all part of the physiopathology of iNPH.

- Most of the time, the disease starts with CSF disturbances.
- Hakim’s triad can be explained by cerebral dyshomeostasis, hypometabolism, and neurotoxicity.
- In iNPH, neurodegeneration is more of a side effect than a pathogenetic factor.
- Before delving into the pathogenesis of NPH, it is important to comprehend the production, circulation, and absorption of CSF as well as their ranges.

**CSF formation**

a. It is generally accepted that now the choroid plexuses, which account for 70–80% of CSF production, are indeed the primary sites of CSF production. Here, CSF is filtered from across capillaries’ endothelial walls and secreted through to the choroidal epithelium. Since the formation of CSF is thought to be an active process independent of intracranial pressure, hydrocephalus will result from a blockage of the CSF pathways (Oresković, 2010). The following is the typical pathway for CSF from production to clearance:

b. The cerebral spinal fluid (CSF) leaves the choroid plexus and travels through the lateral ventricle, interventricular foramen of Monroe, third ventricle, cerebral aqueduct of Sylvius, fourth ventricle, two lateral foramina of Luschka, one medial foramen of Magendie, subarachnoid space, arachnoid granulations, Dural sinus, and ultimately the venous drainage. The Dural sinus, the subarachnoid space, the arachnoid granulations, two medial foramina of Luschka, yet another medial foramen of Magendie, and eventually into to the venous drainage. (Pickard, 1988)

**Circulation of the Cerebro spinal fluid**

It is thought that the pulsatile pumping action of the choroid plexuses, which is produced either by the filling or draining into choroid plexuses, is what causes the flow of CSF (Di Chiro). The CSF is pushed out of the ventricles and into the SAS by each choroid plexus pulse. Furthermore, there is a certain CSF flow into the spinal SAS, presumably at a lower intensity. (Weed L. H., 1935)

**CSF Absorption**

It has long been believed that the Dural venous sinuses arachnoid villi serve as the primary site of CSF absorption. According to a hydrostatic gradient, CSF is thought to be passively consumed from the cranial SAS to the cranial venous blood (Pudenz, 1957). The villi on the arachnoid granulation were originally defined as an open tubular system that protruded into the venous sinus.

**RANGES OF CSF**

0.20-0.35 mL/min of CSF are produced normally; the choroid plexus, which is housed primarily in the lateral and fourth ventricles of the ventricular system, is responsible for producing most of this fluid. In a healthy individual, the lateral and third ventricles each have a 20 mL capacity. An adult's CSF contains 120 mL in total. (Avery, 2010)

There are several theories and hypotheses for explaining the pathogenesis of iNPH,

**We test three theories:**

1. CSF cannot pass through the ventricular wall.
2. Ventricular CSF seeps into the parenchyma, where it is effectively absorbed.
3. Ventricular CSF seeps into the parenchyma but is ineffectively absorbed.

There are three main categories when it comes to hypotheses: circulation theory, which is a widely accepted theory for the emergence of hydrocephalus, lacks sufficient support in both clinical and experimental contexts. (Krishnamurthy, 2014)

Nevertheless, there is substantial evidence that osmotic gradients, which are also present in these other water-permeable organs of the body, are responsible for the water content of the brain ventricles. (Oresković, 1991) Consequently, osmotic gradient changes and hydrocephalus result from brain disorders that produce too many macromolecules in the ventricular CSF. According to
(Orešković, Development of hydrocephalus and classical hypothesis of cerebrospinal fluid hydrodynamics: facts and illusions. , 2011) there's only a slight connection between the theory of macromolecules as well as osmotic gradients.

This review encompasses several key findings that have been noted to be important in the genesis of hydrocephalus, including but not limited to the drainage of CSF through the olfactory pathways and cervical lymphatics, the paravascular pathways and the role of venous system. We propose that as osmotic gradients play an important role in the water transport into the ventricles, the transport of osmotically active macromolecules plays a critical role in the genesis of hydrocephalus. (Krishnamurthy S. &., 2014) Current evidence points to a paravascular and/or lymphatic clearance of these macromolecules out of the ventricles and the brain into the venous system. Therefore, we can view hydrocephalus as a disorder of macromolecular clearance, rather than circulation.

The following are the three theories that explain the pathogenesis of hydrocephalus,

1. CIRCULATORY THEORY
2. OSMATIC GRADIENTS
3. MACROMOLECULAR CLEARANCE

THE CONCEPT OF CIRCULATORY THEORY

Circulation theory states that CSF is actively produced from choroid plexuses in the ventricles and flows from the lateral ventricles through the foramen of Monroe, the third ventricle, aqueduct, the fourth ventricle, and then through the foramen of Luschka and Magendie into the subarachnoid space (SAS) where it is passively absorbed into cranial venous sinuses into the blood (Simon T. D.-C., 2008). Circulation theory was proposed a century ago and is based on three key premises (Warf, 2005) The active formation or secretion of CSF(Dandy, An experimental and clinical study of internal hydrocephalus. , 1913), the passive absorption of CSF, and the unidirectional flow of CSF from the place of formation to the place of absorption. These premises led to the description of CSF circulation as the third circulation (after blood and lymphatic circulations).

THE PARTICULARS SUPPORTING CIRCULATORY THEORY

The theory stating that the choroid plexus is the main source of CSF formation is further challenged by the observation that the volume and composition of CSF do not change when choroid plexuses have been removed. Dandy and Black fan [1913] were the first to induce experimental hydrocephalus by obstructing the aqueduct in a dog using a cotton pledge in a capsule. Aqueductal stenosis has been associated with hydrocephalus and considered to be causative. Aqueductal stenosis has been shown to follow the development of hydrocephalus in both animal models (WILLIAMS, 1973) and in humans. (Klarica, 2009)

First, aqueduct obstruction without induced inflammation did not result in the dilatation of ventricles or even an increase in pressure compared to control animals. (Shapiro, 1987) Secondly, there is no evidence to pinpoint the exact routes taken by the CSF from the choroid plexus in the lateral ventricles through the aqueduct. In fact, Fenstermacher showed that 14C sucrose, when injected into the lateral ventricles, moves into the third ventricle and onto the basal cisterns through the roof of the third ventricle before going into the aqueduct.

If obstructions in the CSF pathways drive the development of hydrocephalus, there should be a corresponding change in the trans mantle pressure gradients. Trans mantle pressure gradient is the difference between the intraventricular pressure and the pressure in the SASs. This gradient has been hypothesized to be the driving force of ventricular dilatation.

OSMATIC GRADIENTS THEORY OF PATHOGENESIS

The idea that brain parenchyma is immune to CSF and unable to absorb the CSF that builds up in the ventricles is one of the fundamental presumptions of circulation theory. However, water can pass through the brain parenchyma. The specific ion channels that permit water to move with ions as well as aquaporin channels that permit water to flow freely without affecting the ionic environment make up the molecular basis of this permeability. Membrane proteins known as aquaporin channels permit water to move with ions as well as aquaporin channels that permit water to flow freely without affecting the ionic environment.

We'll investigate how osmotic gradients affect the pathogenesis of hydrocephalus. Osmotic gradients, except for the ventricular space, are known to affect brain tissues both in normal and abnormal states based on clinical signs. Osmotic diuretics, like mannitol, are given intravenously in the case of brain edema to remove water from the extracellular space of the brain. Hyponatremia can cause brain swelling by allowing water to permeate into the brain's tissues and cause cerebrovascular edema. (Pickard, 1988)

Water is transported into the compartment from the blood. When hydrocephalus is identified, those that accumulate on the membrane's outer edge are the main reason for the elevated protein levels in the CSF fluid. Higher concentrations of thrombopoietin, ferritin, chondroitin sulfate proteoglycan, transforming growth factor beta 1, vascular endothelial growth, and transforming growth factor beta 2 were found in the ventricular CSF of patients with intraventricular hemorrhage-induced hydrocephalus. (Shapiro, 1987)

Our experimental studies have shown that infusing hyperosmolar dextran into cerebral ventricles alters the CSF osmotic gradient, resulting throughout hydrocephalus. Furthermore, the consequence of hydrocephalus increases in direct correlation with a rise in
osmotic load in the ventricles. Other researchers also have affirmed that osmotic gradients play a role in the development of hydrocephalus (90-92). These findings imply that water transport further into the right ventricle is unrelated to osmotic load or the number of macromolecules present.

MACROMOLECULAR CLEARANCE

Para vascular and lymphatic pathways are the underlying mechanisms that help with the clearance of macromolecules. We found that macromolecules infused into the ventricles are cleared through the brain parenchyma along the perivascular spaces and along the cribriform plate into the nose. (Krishnamurthy S. L., 2018) These findings show that the macromolecules infused into the ventricles or intrathecal spaces are distributed in the para-vascular pathways, these pathways are also termed the glymphatic pathways or system.

Where do the macromolecules transported through the Para vascular pathways go. (Klebe, 2020) found that the particulate matter that is injected is rapidly and efficiently ingested by perivascular cells. The authors summarized these findings in a review article and highlighted both the Para vascular and nasal lymphatic pathways and their immunological significance. The authors proposed that this absorption of the macromolecules by immunologically competent cells as an explanation for immune-mediated CNS disorders. The exact mechanism of macromolecular clearance outside of the brain is uncertain.

SUMMARY AND INTERLINK BETWEEN THE THREE THEORIES

A. Hydrocephalus is a complex condition caused by several different disorders.

B. The circulation theory, while widely accepted as being representative of how hydrocephalus develops, lacks adequate evidence in clinical or experimental settings.

C. There really is strong evidence that osmotic gradients, like those found in other water-permeable organs, have become willing to accept responsibility for the water content of both the brain ventricles. Any illness that causes an increase in macromolecules in the ventricular fluid alters the osmotic gradient and causes hydrocephalus.

Likewise, we can consider hydrocephalus to be a macromolecular clearance disorder. Evidence suggests that these macromolecules are cleared from the ventricles and brain into the venous system via perivascular or lymphatic pathways. While there are a few gaps in this pathophysiological construct as well, it appears to have a lot more backing.

INVESTIGATIONS:

The International Guidelines have recommended the following key imaging features for diagnosis of iNPH and selection of shunt-responsive patients:

1. Ventricular enlargement not entirely attributable to cerebral atrophy or congenital enlargement (Evans index >0.3).
2. No macroscopic obstruction to CSF flow.
3. At least one of the following supportive features:
   a. Enlargement of the temporal horns of the lateral ventricles not entirely attributable to hippocampus atrophy.
   b. Callosal angle of 40º or greater.
   c. Evidence of altered brain water content, including periventricular signal changes on CT and MRI not attributable to microvascular ischemic changes or demyelination.
   d. An aqueductal or fourth ventricular flow void on MRI.

- The most commonly used radiological criteria in the diagnosis of hydrocephalus are given below [12, 13] (Figures 1 and 2):
- 1. Ventricleomegaly (Evans’ index >0.3),
- 2. Enlargement of the third ventricular recesses and lateral ventricular horns,
- 3. Decreased mamillary distance and frontal horn angle,
- 4. Thinning and elevation of the corpus callosum,
- 5. Normal or narrowed cortical sulci,
- 6. Periventricular white matter hyperintensities (interstitial oedema and acute hydrocephalus),
- 7. Aqueductal flow void phenomenon in T2W images
- (a sign of communicating hydrocephalus).
These criteria are not specific for hydrocephalus, and their sensitivities are poor [13]. The gold standard diagnostic method for hydrocephalus is ventriculographic studies [6]. The most commonly used radiological criteria in the diagnosis of hydrocephalus are given below [12, 13] (Figs. 1 and 2):

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for hydrocephalus is ventriculographic studies [6///]The diagnosis of hydrocephalus is generally made using a combination of clinical signs, findings on radiological imaging, and, on some occasions, CSF pressure readings. In children, a bulging frontal fontanelle indicates increased intracranial pressure. Ultrasonography or computed tomography will show ventriculomegaly and possibly help reveal the cause of hydrocephalus.

**CSF REMOVAL:**

A high-volume (> 30 mL) spinal tap (lumbar tap test) was the earliest method for establishing the diagnosis of iNPH and predicting response to shunting, and external lumbar drainage (ELD). A lumbar spinal catheter is inserted, and CSF is drained at a rate of 10 to 15 cm² per hour for 72 hours. (Shooman, 2009) Although a commercially available automated gait analysis system is available to quantify response to ELD walking speed can also be measured using a timed 10-meter walk before and after ELD.

**COMMORBID CONDITIONS –**

These deal with the comorbid conditions that occur during the pregnancy, they are ruled out in the following -

A. **GESTATIONAL DIABETES**
B. **HYPERTENSION**
C. **THYROID**

The above conditions are placed according to the rate of incidence they occurred in many review cases.

**A. GESTATIONAL DIABETES**

It is the first major condition that causes hydrocephalus in infants, and its incidence rate is high when compared to the other causes that have been ruled out. Journal of Biological Science reports that (Jacobs, 1977) maternal diabetes is linked to an increased risk of congenital abnormalities and growth deformities in the infant. Mothers with maternal diabetes may have a more permeable blood-brain barrier, which could increase the production of CSF and result in brain disorders like hydrocephalus. According to Lawrence Jacob et al. (GHORBANI, 2009), interaction of hypothalamic and brainstem autonomic structures by the increasing ventricles even during evolution of hydrocephalus might indeed result in diabetes coexisting of normal pressure hydrocephalus.

**B. HYPERTENSION –**

Several more articles explain the causes of eclampsia or maternal pregnancy which lead to subset impacts on hydrocephalus arising in congenital condition, and one of those articles is a review of obstetric and perinatal outcome in hypertension. This is the second significant comorbid condition that indirectly causes hydrocephalus. According to Sreelatha S. Kamala (Sreelatha, 2018), decrease in placental blood flow. Your baby may get less oxygen and fewer nutrients if the placenta doesn't get enough blood. Low birth weight, intrauterine growth restriction, and preterm birth can result from this. According to their case study, they observed that 2/3 of the mothers had hypertension during pregnancy, which may be one reason why some kids are born with congenital hydrocephalus. These led us to the conclusion that pregnant women with hypertension could even lead to hydrocephalus. (Gruber, 2010)

**C. THYROID:**

It is another leading cause of hydrocephalus which develops because of abnormal thyroid hormone levels during pregnancy. The newborn rat can indeed be evaluated by comparing to a human fetus in the second trimester of pregnancy, as well as the newborn human baby to such a 6–10-day old rat, according to (Noonan, 1963). The hypothyroid brain exhibits numerous structural flaws, due to a decrease in neuropil, the cerebral cortex's cell density has increased. Decreased cell counts in areas where postnatal cell acquisition is significant. significantly reduced GABAergic interneuron density and increased neuronal precursor density in the cerebellum Parvalbumin interneurons are less numerous in the cerebral cortex.

**CONCLUSION:**

The clinical signs of hydrocephalus vary greatly from one person to another, depending on age, disease progression, and individual acceptance to the circumstance. Infants and young children. For instance, seem to be more vulnerable to symptoms of elevated intracranial pressure, such as vomiting, whereas adults may undergo loss of function, such as trying to walk or thinking. The capacity of an infant to compensate for increased CSF pressure and ventricle enlargement differentiates in comparison to an adult. Since the sutures (the fibrous joints that connect the bones of the skull) have not yet been forced to close, the infant skull could indeed broaden to accommodate the buildup of CSF.

The important point of socioeconomic factors is indeed a malnourished mother during her pregnancy, which results in atypical fetal growth and contributes to congenital hydrocephalus. Whenever a mother is malnourished, the fetus does not obtain all the necessary nutrients and essential elements for the overall mental and physical development of both the body. In such cases, the fetus develops tubercular meningitis, a condition that is a general precursor for infantile normal pressure hydrocephalus, maternal nutritional deficiencies are a prevalent consequence of fetal growth retardation, central nervous system malformations including such spina bifida and hydrocephalus, and prematurity.
Since pediatric hydrocephalus is a condition that often affects children living in poverty and poses a socioeconomic barrier because of postponed shunt procedures designed to lengthen patient lifespans, this study was conducted to assess the effectiveness of supportive therapy in treating the condition. Our study focused on supportive therapy, which includes the use of diuretics like carbonic anhydrase inhibitors and loop diuretics because they are known to have important therapeutic efficacy in the treatment of hydrocephalus.

References