Fourth Ventricle Entrapment; a rare complication of ventriculoperitoneal shunt surgery: A Case Report

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Abstract

A uncommon side effect of ventriculoperitoneal shunt surgery is trapped fourth ventricle, often referred to as isolated fourth ventricle, which is marked by blockage of the cerebral aqueduct or exit. Cerebrospinal fluid accumulates as a result. According to this case report, a 7-year-old patient with a history of ventriculoperitoneal shunt developed a trapped fourth ventricle and manifested memory loss, weakness, and abnormal gait. To allow for the outflow of cerebrospinal fluid from the fourth ventricle, the patient had arachnoid dissection (adhesiolysis) and open posterior fenestration of the fourth ventricle's midline. After a ten-day hospital stay, the patient was released following a successful surgery. In order to avoid major difficulties, this research emphasises the importance of early detection and treatment of a trapped fourth ventricle.

Entrapped Fourth Ventricle

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- ? **Fazeela Bibi** : Conceptualized the study, drafted the manuscript, and supervised the project.
- ? **Muhammad Ibrahim** : Collected clinical data and contributed to patient diagnosis and management.
- ? **Rehmat Farhaj** : Conducted literature review and provided input on case relevance.
- ? **Ihsan Ullah** : Analyzed and interpreted data, contributing to manuscript revisions.
- ? **Barkah Ali** : Assisted in patient care and detailed the clinical findings for the report.
- ? **Prerana MN** : Contributed to case diagnosis and highlighted differential diagnoses.
- ? **Raghvendra Singh** : Reviewed and interpreted imaging and diagnostic investigations.
- ? **Javed Iqbal** : Provided nursing care insights and assisted with patient follow-up data.
- **Vohra Maham Hassan:** Review and Editing, for creation of the published work.
- ?**Bilal Aslam:** Validation and Visualization, of the overall preparation of the published work.

Syed Muhammad Ali: Management and coordination responsibility for the research activity planning and execution.

Data Availability Statement

"The data was taken from a patient who presented to our hospital, all data and references are publicly available on databases such as Pub-med and Google Scholar."

Abstract:

A uncommon side effect of ventriculoperitoneal shunt surgery is trapped fourth ventricle, often referred to as isolated fourth ventricle, which is marked by blockage of the cerebral aqueduct or exit. Cerebrospinal fluid accumulates as a result. According to this case report, a 7-year-old patient with a history of ventriculoperitoneal shunt developed a trapped fourth ventricle and manifested memory loss, weakness, and abnormal gait. To allow for the outflow of cerebrospinal fluid from the fourth ventricle, the patient had arachnoid dissection (adhesiolysis) and open posterior fenestration of the fourth ventricle's midline. After a ten-day hospital stay, the patient was released following a successful surgery. In order to avoid major difficulties, this research emphasises the importance of early detection and treatment of a trapped fourth ventricle.

Keywords: Isolated Fourth Ventricle (IFV), Trapped Fourth Ventricle (TFV), Ventriculoperitoneal Shunt (VP Shunt), Hydrocephalus, Aqueductoplasty, Arachnoid Dissection.

Introduction:

Hydrocephalus is a pathological condition where cerebrospinal fluid (CSF) accumulates due to increased production, obstructed flow or reduced absorption, causing ventricles to expand and potentially damaging brain tissue. It can be congenital or acquired and is classified into non-communicating (CSF cannot flow through ventricles (e.g., cerebral aqueduct stenosis) and communicating hydrocephalus (flow of CSF is obstructed outside the ventricles, such as in the sub-arachnoid space). Common causes include genetic defects, infections, trauma, and central nervous system (CNS) tumours. Symptoms include headache, nausea, blurred vision, and cognitive decline, and diagnosis is confirmed by imaging methods such as CT or MRI [4].

In children, hydrocephalus is a major cause of morbidity, with rates of (30-423) cases per 100,000 children, higher in developing countries. Primary aqueduct stenosis, Dandy-Walker malformation, and Chiari malformations are some disorders that might result in congenital hydrocephalus, while acquired hydrocephalus has been reported in the literature to arise from intracranial infections, haemorrhages, or tumours [1, 2]. CSF is synthesised by the choroid plexus, and it circulates through the ventricles, with obstacles resulting in elevated ICP or hydrocephalus. The Monro-Kellie principle prposes surged ICP is secondary to elevated levels of CSF, resulting in damage to brain tissue through trans-ependymal flow and atrophy [3].Ventriculoperitoneal (VP) shunts are nowadays in practice to cure hydrocephalus by shifting extra CSF to the peritoneum, though they can also drain to the pleura or heart. Congenital hydrocephalus, tumours, infections, myelomeningocele, craniosynostosis, and normal-pressure hydrocephalus are reported to be the main indications for VP shunts [5]. However, VP shunts carry a complication rate of 2-20%, with potential issues like infection, haemorrhage, shunt malposition and obstruction [5].

A rare consequence of VP shunts is TFV, where CSF builds up in the ventricle due to blockage of the aqueduct and exit foramina. One rare, late result of shunting the lateral ventricles for hydrocephalus, is the 'encysted' or solitary enlargement of the fourth ventricle [12]. Patients who have had several shunt procedures are most likely to experience this disease, which can cause cerebellar and brainstem compression, worsen hydrocephalus, and perhaps lead to neurological impairments. Patients with a history of multiple shunt procedures should be closely monitored for TFV [6, 9].

Surgery is typically advised when patients show symptoms of brainstem compression or a trapped fourth ventricle gets markedly worse [13].

Patients with VP shunts require regular monitoring for complications like headaches, vomiting, or neurological changes, which may indicate shunt failure. Early identification through imaging and clinical assessment is essential for preventing further damage. An interprofessional team—including paediatricians, surgeons, and radiologists—plays a critical role in managing shunt-related complications [7, 8, 10]. Endoscopic approaches for hydrocephalus include supratentorial techniques using ventriculomegaly for safe navigation. Aqueductoplasty is followed by stent insertion to connect the third and fourth ventricles [11]. Given its minimally invasive nature, higher efficacy, durability, and comparable safety to shunt installation, endoscopy ought to be the first-line treatment for TFV [14].

Case Description:

A seven-year-old patient reported to opd with complaints of drowsiness, gait disturbances and episodic loss of consciousness accompanied by a history of irrelevant mumbling for two weeks. Furthermore, sleep irregularities and disturbed behaviour were present. The patient's weight was measured to be 14 kg. On enquiring further, a past surgical history of a ventriculoperitoneal (VP) shunt procedure done two years ago, in view of traumatic hydrocephalus, was elicited. During this episode, the patient reportedly had symptoms of sudden loss of consciousness and postprandial vomiting. On admission and evaluation, the diagnosis of post-traumatic hydrocephalus was made, and prompt elective surgical intervention was done. The patient recovered and was alert and playful post-surgery. No postoperative complications were documented.

On examination, the patient Glasgow Coma Score at presentation was E4 V3 M5 (13/15) with normal tone and reflexes. On visual examination, both eyes were normal.

A CT scan was performed, which revealed a hyper dense opacity in the posterior cranial fossa. It was initially thought to be a cystic lesion, and tumour resection via craniotomy was planned. As a confirmatory investigation, MRI was performed, which revealed that it was not a cystic lesion but, in fact, the fourth ventricle which was distended, and the patient was found to have a TFV [figure-1].

After clinching the diagnosis, intravenous (IV) antibiotic cefoperazone + sulbactam (1 gm) twice a day, anti-epileptic in the form of levetiracetam (250 gm) IV twice a day and dexamethasone (1 mL) IV four times a day were administered, and the appropriate management for pyrexia and vomiting was planned. After obtaining consent and preoperative preparation, open posterior fenestration of the midline of the fourth ventricle along with arachnoid dissection (adhesiolysis) was done.

Postoperatively, the patient was found slightly irritable due to a mild headache. No seizures or other post-procedural complications were noted, following which oral intake was started after 12 hours. Post-operative CT was performed, and the location of the shunt as well as the status of the ventricles was ascertained [figure-2]. IV cefoperazone + sulbactam and levetiracetam for seizure prophylaxis were prescribed, before discharging, on discharge medications including cefoperazone + sulbactam (1 gm) IV twice a day and syrup sodium valproate (250 mg/5 ml) twice a day. Adequate counselling to the family about home care measures, the importance of compliance with medication and follow-up was given.

Discussion:

Only a small number of cases of TFV, often referred to as IFV are documented in the previous studies. [14]. When the cerebral aqueduct of Sylvius and the exit foramina, , are closed, it happens[15]. The choroid plexus produces and secretes CSF and is found at the centre of the brain. Lymph veins and arachnoid granulations collect CSF close to the skull. It implies a lengthy flow pathway. CSF must go from the lateral ventricles to the third ventricle and finally to the fourth through its natural course [16]. When there is any pathology, then cerebrospinal fluid (CSF) will gradually accumulate as a result, first creating a displacement of the cerebellum and then moving on to the brainstem anteriorly.Although the precise process causing the fourth ventricle to become confined is not entirely understood, it is more frequently observed in individuals who have undergone numerous shunt surgeries, post-infectious hydrocephalus, and Youmans's isolated fourth ventricle (IFV) [17].

Large anatomical spaces, such as the ventricles and subarachnoid cavity, are in close proximity to perivascular

regions and nerve sheaths, facilitating systemic circulation and the transfer of solutes [16]. However, the complications associated with fourth ventricle shunting remain insufficiently explored. A recent review by Lee et al. detailed the management of 12 patients with trapped fourth ventricles and associated cysts linked to Dandy-Walker malformations. In three instances, direct damage to the fourth ventricular floor impeded the proper placement of a catheter in the posterior fossa. One individual experienced an intracystic hemorrhage due to shunt failure [18]. Additionally, five of the seven patients in our study exhibited slit lateral ventricles (unilateral or bilateral) connected to an isolated fourth ventricle, a finding consistent with other reports [19–24].. Headache, uncoordinated movements, coma, cranial nerve lesions, anorexia, and vomiting are all indications of an isolated fourth ventricle [23]. The premature newborns treated for hydrocephalus following intraventricular haemorrhage (IVH) had the most frequent clinical presentation [25].The fourth ventricle cavity's volume growth and the resulting compression on the surrounding neurological structures—the brainstem, lower cranial nerves, and cerebellum—are linked to the most frequent clinical sequel. The end outcome of that occurrence is a condition known as posterior fossa syndrome, which manifests clinically similarly to an increasing posterior fossa tumour. Patients first experience headaches, emesis, and irritability in addition to cerebellar and bulbar dysfunction [11].

The implications of isolating the fourth ventricle and identifying the signs that make its care critical are two further issues that warrant extra surveillance. The cerebellum's posterior displacement and compression are the initial signs of growing fourth ventricle dilatation. This is followed by anterior relocation of that entity and the onset of brain stem deformation. The inflated fourth ventricle's upper herniation is a frequently noticed phenomenon. Common manifestations include deconjugate eye movements, poor eating, truncal instability, and somnolence. Acute or subacute IFV is less frequent and is linked to bleeding or infection during diagnosis [26-28].

Other study results demonstrate that in clinically deteriorating patients with neurosarcoidosis and ventriculoperitoneal shunting, an isolated fourth ventricle must be taken into consideration as a differential diagnosis. Granulomatous inflammation of the periventricular tissue may be the origin of the meningeal contrast enhancement at the fourth ventricle's outputs. This inflammation ultimately resulted in the establishment of the ailment[29] . After lateral ventricular shunting, the symptoms often go away entirely so ventricle returns to normal and needs to be shunted. It can be distinguished from other pathologies, like cystic tumours, by paying close heed to denseness and presentation on CT [15].

MRI is frequently used to confirm the issue of discrepant dilatation, which is commonly identified by cranial ultrasonography. Diagnosis is confirmed when an enlarged "ballooned" fourth ventricle is observed. Compression of the surrounding structures, membranous blockade of the aqueduct of Silvius, effacement of the cerebellar tissue, flattening of the posterior aspect of the brainstem, and decreased CSF in the prepontine cistern due to ventral displacement of the brainstem are also frequently present [30, 31]. Furthermore, MRI can be utilised to distinguish between cystic lesions, shunt dysfunction, and a TFV. Compression of the brainstem and cerebellum, herniation through the tentorial notch on preoperative imaging, structures and length of CSF containing parts, all influence treatment choices [32, 27].

Cranial nerve palsy after shunt implantation is rare in an IFV. In some instances of IFV, catheter damage to the nuclei of the brainstem is believed to cause nerve dysfunction. A young patient was reported to develop dysfunction of the abducent, facial and hypoglossal nerves some days after shunt placement[33]. Another study showed that treatable polyneuropathies resulted after acute decompression of the structure[34]. Multiple cranial nerve impairments that affect both sides are extremely rare. As far as we are aware, there has only been one case documented in the literature. In a report of a young patient who had undergone implantation of a low-pressure fourth VP shunt, three months following the procedure a CT scan was done which demonstrated the ventricular shrinking with the child having symptoms like bilateral abducent nerve palsies and vomiting. After switching to "a medium pressure" system for the valve, these problems subsided [35].The basic principle of the management of a fourth ventricular trap is to facilitate CSF drainage, thereby alleviating compression over vital structures. A wide range of options are available for management, with a variety of non-invasive measures ranging from observation and monitoring, periodic neurological examina-

tion and imaging for asymptomatic cases, medical measures like intra-cranial pressure lowering drugs, shunt adjustment and rehabilitative measures. Severe cases might require surgical management, including fourth ventricular shunting, endoscopic third ventriculostomy and aqueductoplasty. In less complicated cases when other procedures are not viable, shunting with a Y connector stands out to be an appropriate choice [36]. Prompt treatment of fourth ventricular trap can ensure relief from features of raised ICP and life-threatening compressive features encompassing nerve lesions, dysphagia and dysarthria, thereby preventing neurological damage. Timely intervention can also prevent regression of developmental milestones in children, minimise irreversible neurological damage and improve surgical outcomes [9, 11].

Treatment of the fourth ventricular trap, whether surgical or non-surgical, poses a risk of certain complications like shunt blockage, over-drainage leading to ventricular collapse, damage to the adjacent structures, CSF leak and risk of infection, in addition to the neurological deficit that might occur due to the progression of the condition [9]. Amongst these, the risk of infection is one of the most common complications, which might be acquired through exogenous or endogenous (haematogenous) routes. Generalised features of fever, irritability, lethargy, signs of inflammation along the shunt track, symptoms suggestive of peritonitis and neurological features suggestive of shunt failure, including signs of raised ICP and altered mental status, can develop. After confirming the diagnosis through blood cultures, CSF analysis and imaging, a shunt is removed, followed by draining, and usage of intravenous bactericidal drugs. Reapplication of a new shunt is planned later on. The prognosis after prompt treatment of trapped fourth ventricles is dependent on multiple factors, including but not limited to the treatment modality employed, time elapsed, presence of an underlying condition, age and overall health status of the patient. Most patients do experience symptomatic relief, particularly marked with respect to headache, vomiting, ataxia and cranial nerve deficits evidenced by the reduction in the length of cavity on imaging. Timely intervention also curtails the risk of long-term neurological deficits and developmental delays, although certain issues such as shunt dependency and infection can arise. Early diagnosis and intervention reduces the chances of irreversible neurological deficits and improves the long-term outcomes, improve survival as well as quality of life in such children, while reducing the risk of complications. In view of the potentially life-threatening complications that can arise, long-term follow-up and monitoring are extremely vital. This will facilitate early detection of complications and thereby a better neurological outcome. Additionally, any recurrence due to scarring, blockage of shunt or infection can be detected before significant symptoms arise. It can be done by serial imaging in addition to monitoring of symptomatic improvement and assessment of developmental milestones attained. The aspect of psychosocial support is indispensable in such cases, more so with complications or neuronal deficits [11].

Conclusion:

TFV is a rare but serious impediment of ventriculoperitoneal shunt surgery and requires prompt diagnosis and intervention. This case highlights the importance of recognising clinical signs of TFV, using improved imaging to make an accurate diagnosis, and restoring CSF dynamics using appropriate interventional techniques. Early intervention not only reduces symptoms, but also prevents brain dysfunctions and provides better patient outcomes. The report emphasises about physicians treating patients with VP shunts need to remain vigilant to quickly identify and treat such problems.

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Figure legend:

[figure-1: Pre operative MRI Brain showing hyperdense lesion in the posterior cranial fossa]

[figure-2: Post operative CT scan showing craniotomy defects in the right occipital and right frontal bones, dilation of ventricular chain with pneumocephalus, with VP shunt in place]