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Bilateral abducens and facial nerve palsies following fourth ventriculoperitoneal shunt with laparoscopic-assisted abdominal catheter placement

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ABSTRACT

Introduction: Hydrocephalus, altering cerebrospinal fluid (CSF) dynamics, affects 175 per 100,000 adults worldwide. Ventriculoperitoneal shunts (VPS) manage symptomatic hydrocephalus, with 125,000 cases annually. Despite efficacy, VPS face complications, necessitating interventions.
Research question: "What are the mechanisms and risk factors for bilateral VIth and VIIth lower motor neuron palsies in hydrocephalus patients with a fourth ventriculoperitoneal shunt?"
Material and methods: This study details a 36-year-old female with a neonatal meningitis history, multiple shunt replacements, admitted for abdominal pain secondary to pelvic inflammatory disease. An abdominal shunt catheter removal and external ventricular drain placement occurred after consultation with a general surgeon. A cardiac atrial approach and subsequent laparoscopic abdominal approach were performed without complications.
Results: After one month, the patient showed neurological complications, including decreased facial expression, gait instability, and bilateral VIth and VIIth lower motor neuron palsies, specifically upgazed and convergence restriction.
Discussion: The complication's pathophysiology is discussed, attributing it to potential brainstem herniation from over-drainage of CSF. Literature suggests flexible endoscopic treatments like aqueductoplasty/transaqueductal approaches into the fourth ventricle.
Conclusions: This study underscores the need for increased awareness in monitoring neurological outcomes after the fourth ventriculoperitoneal shunt, particularly in cases with laparoscopic-assisted abdominal catheter placement. The rarity of bilateral abducens and facial nerve palsies emphasizes the importance of ongoing research to understand pathophysiology and develop preventive and therapeutic strategies for this unique complication.

1. Introduction

Hydrocephalus results from increased cerebrospinal fluid (CFS) production and reduced absorption or blockage at any point in CFS circulation, affecting approximately 175 per 100,000 adults worldwide (Isaacs et al., 2022). The etiology can be either noncommunicating or communicating (Karasin et al., 2021). Ventriculoperitoneal shunts (VPS) are a standard surgical and lifesaving treatment for patients with

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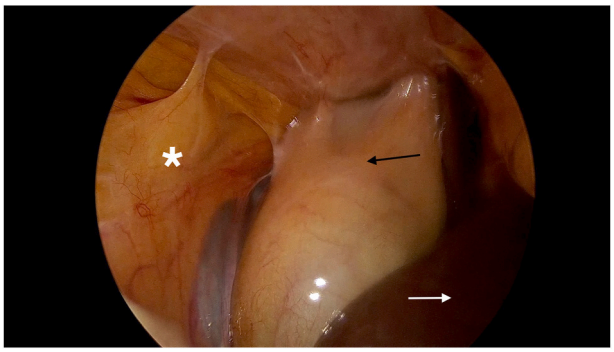

Fig. 1. Laparoscopic view of the enlarged gallbladder (black solid arrow), right hepatic lobe (white solid arrow), and abundant intra-abdominal adherences (white asterisk) before distal shunt placement.

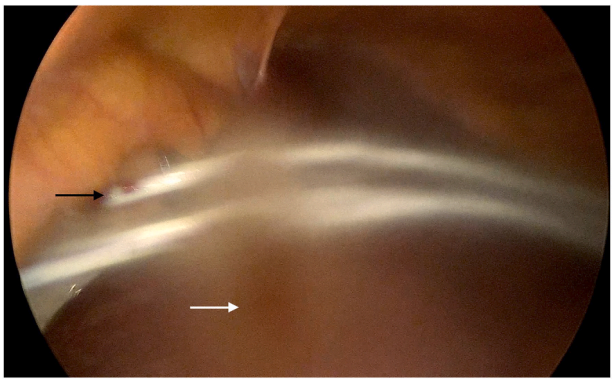

Fig. 2. Laparoscopic view after distal shunt placement without pneumoperitoneum due to catheter entrance. The tip of the distal portion of the catheter (black solid arrow) is located immediately above the right hepatic lobe (white solid arrow).

Fig. 3. Upgazing and convergence restriction, normal pupil reaction, and bilateral VIth and VIIth lower motor neuron palsies.

symptomatic hydrocephalus, initially described in 1908, with approximately 125,000 cases every year (Naftel et al., 2011; Cohen-et al., 2014). A normal brain produces and absorbs approximately 400–600 mL of CSF daily at 20 mL/h (Conen et al., 2008).

These devices will likely fail over time because of obstruction, infection, tethering, pseudocyst formation, or tubing fracture, which might require one additional or multiple operations to replace the shunt device (proximal or distal) (Johnson and Pimpalwar, 2009). In children, distal mechanical failure is approximately 70%, and in adults, postoperative complications can be as high as 38% (infection, hygroma, or over-drainage) (Hadjiathanasiou et al., 2020).

Mini-laparotomy is a traditional abdominal access procedure that is primarily performed by neurosurgeons (Naftel et al., 2011). Laparoscopy has potential benefits in the placement of VPS in patients with complex abdominal anatomy due to prior abdominal surgeries. Other anatomical structures, such as the pleura and right atrium, have been used as alternatives to the abdominal cavity (Cohen-et al., 2014).

Atrial shunt placement was first described in children, with significant limitations due to progressive withdrawal of the cardiac tube resulting from growth and cardiac complications, such as endocarditis, tricuspid endocarditis, cardiac tamponade, neurologic pulmonary edema, mycotic pulmonary artery aneurysm, superior cava thrombus, and non-cardiac complications, such as glomerulonephritis (Vella et al., 1995; Miramontes et al., 2010; Bellamy et al., 1990; Chaw et al., 2004; Kikuchi et al., 2012; Cruz et al., 2016; Gelfand and Callaghan, 1981; Steele et al., 2018).

Fourth ventricle shunt placement is not a usual surgical shunt placement and is reserved for unusual requirements such as Dandy-Walker syndrome and posterior fossa cyst formation with subsequent ventricular entrapment. Some patients may also require supra-and infratentorial shunt systems. Cranial nerve palsy is an infrequent condition described in the pediatric population and is less common in adulthood. This paper describes a complex case of bilateral abducens and facial nerve palsies after supra-infratentorial ventricle shunting using a complex abdominal surgical approach.

2. Materials and methods

We present a representative case of a 36-year-old female with a relevant past medical history of neonatal meningitis with subsequent hydrocephalus and multiple supra/infratentorial shunt replacements with secondary hardware malfunction (2008, 2015, 2021). She was admitted to the hospital in December 2021 for acute abdominal pain secondary to pelvic inflammatory disease. After the general surgeon consulted a contrast-enhanced abdominal pelvic CT scan, the presence of an abscess surrounding the uterus was concluded. No surgical intervention was performed, but the abdominal shunt catheter was removed because of the high risk of contamination, and an external ventricular drain was proposed and accepted by the patient and family. No bacterial growth was observed in the CSF. Therefore, a cardiac atrial approach was suggested and performed without complications, merging both supra and infratentorial catheters into a "Y" shape connector to create only one distal catheter, with no antisiphon device.

As an outpatient, she presented with shunt dysfunction and symptoms such as headaches and vomiting. Most symptoms were alleviated after manual pumping of the valvular reservoir and corroborated on head CT before and after the maneuver. As the abdominal pathology was corrected, the atrial chamber could not provide distal CSF flow. Therefore, abdominal shunt placement was carefully proposed, and in joint efforts with general surgery, a laparoscopic-assisted technique was successfully used. Direct catheter placement was performed with

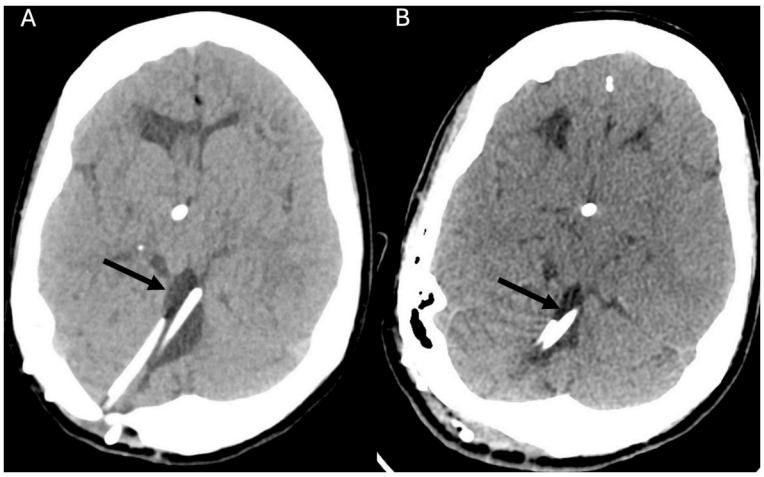

Fig. 4. A) Preoperative. This image shows a computed tomography (CT) scan obtained before revision surgery. B) Postoperative. This image shows a CT scan obtained after successful revision surgery. A significant reduction in ventricle size (black solid arrow) was observed compared to the preoperative scan, signifying improved drainage and potential improvement in hydrocephalus.

laparoscopic assistance, and abundant post-infection adherence was observed, mainly localized to the gallbladder. Figs. 1 and 2.

The patient was discharged from the hospital without neurological complications. During the first-month follow-up visit to the office, the patient complained of decreased facial expression and gait instability while walking along a straight line. On physical examination, she had upgaze and convergence restriction, normal pupil reaction, and bilateral VI^{th} and VII^{th} lower motor neuron palsy. Fig. 3.

Brain computed tomography (CT) and MR were resonance and revealed a very small fourth ventricle. Lowering the valve opening pressure to a minimum could manage most symptoms; therefore, sequential CT scans were obtained to assess the fourth ventricle size. Fig. 4.

3. Discussion

The development of bilateral abducens and facial nerve palsies after a fourth ventriculoperitoneal shunt with laparoscopic-assisted abdominal catheter placement is a rare but serious complication. The pathophysiology of this clinical scenario is not fully understood, but it might be the interaction from brainstem herniation (downward) due to overdrainage of CFS compressing the abducens and facial nerves. Right atrial volume and function measurements have technical difficulties with 2D echocardiography, but magnetic resonance imaging shows better results and can describe atrial filling from the point of minimal atrial volume at the onset of ventricular systole until maximal atrial flow.

The right atrium is a reservoir during ventricular systole that transports blood from the caval and pulmonary veins into the right ventricle. It is the sum of forward and reversed caval flows through the tricuspid annulus. The maximal right atrial volume to atrial volume at the P-wave is the passive emptying volume (Baur, 2008). At a normal right atrial pressure (0 mmHg), the cardiac output will be at its normal value (approximately 5 L/min) for healthy subjects of an average size. As right atrial pressure is reduced below 0 mmHg, cardiac output decreases until, in the normal hermetic chest container, at a right pressure of −2 to −3 mmHg, cardiac output reaches 0 (Patterson and Starling, 1914). Overdrainage can lead to decreased intracranial pressure, which can cause the brainstem to sag and displace the cranial nerves, leading to cranial nerve palsy.

Management of bilateral abducens and facial nerve palsies after a fourth ventriculoperitoneal shunt is challenging. Some symptoms may improve spontaneously with time; however, in other cases, the palsies may be permanent. Torrez-Corso et al. described a flexible endoscopic treatment for complex hydrocephalus using an aqueductoplasty/trans-aqueductal approach into the fourth ventricle in a 20-year-old patient with full recovery of neurological function after a traumatic brainstem injury (Torrez-et al., 2009). In addition, Gallo et al. endorsed the safe and effective technique of endoscopic trans-fourth ventricle aqueductoplasty in the treatment of complex hydrocephalus (Gallo et al., 2012).

4. Conclusions

More research is needed to better understand the pathophysiology of cranial nerve palsy after fourth-ventriculoperitoneal shunt surgery. This study may lead to the development of new strategies to prevent and treat this complication. Atrial shunt placement is more complex than traditional abdominal shunt placement and should be reserved for patients with complex abdominal anatomy.

Declaration of competing interest

The authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bas.2024.102824.

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