Spontaneous Intracranial Hypotension

Spontaneous intracranial hypotension remains an underdiagnosed etiology of new-onset headache.

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Spontaneous intracranial hypotension remains an underdiagnosed etiology of new-onset headache. It was first recognized in 1938 by German neurologist Georg Schaltenbrand, who described multiple patients presenting with spontaneously occurring low cerebrospinal fluid pressure. The condition is classically associated with postural headache, which is relieved by lying down and worsens with sitting or standing upright. In some cases, the headache can become severe enough to cause nausea, vomiting, vertigo, photophobia, blurred vision, phonophobia, and/or tinnitus. It may also be associated with neck stiffness and pain with neck flexion. Otherwise, the physical and neurological examinations are not uncommonly normal.

Cerebrospinal fluid can become reduced in volume through decreased CSF production, increased CSF reabsorption, and CSF leakage. William Bell, et al. classified low CSF pressure syndromes into five categories: 1) spontaneous or primary, 2) postoperative, 3) posttraumatic, 4) post-lumbar puncture or nerve sleeve tear, and 5) secondary to other underlying medical conditions, such as cerebral arteriosclerosis or dehydration. Bell et al. initially proposed choroid plexus dysfunction with reduced CSF secretion as the fundamental cause underlying CSF hypovolemia in most cases. In their report they postulated that postoperative and posttraumatic etiologies of intracranial hypotension likely result from decreased CSF production by the choroid plexus secondary to low cerebral blood flow. They also noted medical conditions such as dehydration and cerebral arteriosclerosis that can lead to inadequate cerebral blood flow, thereby decreasing CSF secretion in the same manner. In terms of spontaneously occurring intracranial hypotension, they proposed the idea of choroid plexus dysfunction secondary to hyperreactive vasospasm of the blood vessels supplying the choroid plexus.

However, recent studies have produced more evidence in favor of direct leakage of CSF as the cause of intracranial hypotension. The post-lumbar puncture headache has been a well-documented event found to occur in patients who develop postural headaches within days of the procedure due to leakage of CSF from the site of dural puncture. A similar mechanism of CSF leakage may occur with lumbar nerve sleeve tears, which have been identified in patients presenting with postural headaches following a fall on the buttocks. Connective tissue disorders with resultant structural abnormalities and weakness of the dura are thought to predispose such patients to leakage of CSF into the epidural space, occurring either spontaneously or following relatively minor trauma. Upon investigation of CSF leakage by imaging studies or surgical exploration, single or complex meningeal diverticula have been found in some patients, demonstrating the underlying weakness of the dura. Connective tissue disorders found to be associated with spontaneous

Figure 1. Midline sagittal T1-weighted image demonstrating a “sagging brain” appearance (blue arrow) with flattening of the anterior margins of the pons and medulla (green arrow). There is loss of the vertical height of the suprasellar cistern and sagging of the tuber cinereum (yellow arrow). There is a prominent pituitary gland (red arrow).
intracranial hypotension include Marfan syndrome, Ehlers-Danlos syndrome type II, and autosomal dominant polycystic kidney disease.

Cerebrospinal fluid fills the subarachnoid space and ventricular system within and around the brain and spinal cord. The fluid functions to provide buoyancy and protective support of the brain, as well as chemical homeostasis. The Monro-Kellie hypothesis states that the incompressibility of the cranial compartment leads to a fixed intracranial volume, such that an increase in one of the cranial components, including blood, CSF, and brain tissue, is met with a decrease in one of the other components, and vice versa. In accordance with this concept, decreased CSF pressure would be compensated for by venous engorgement and reduced buoyancy with subsequent brain sagging. This brain sag may cause downward traction on pain-sensitive neural structures, which produces the presenting headache. Lying in the supine position would then relieve traction and mitigate the headache.

COMPLICATIONS

Complications of intracranial hypotension have been noted to occur in rare cases. Transient abducens nerve paralysis, either unilateral or bilateral, has been observed with intracranial hypotension, caused by downward displacement of the brain in the setting of reduced buoyancy that results in stretching of the cranial nerve. Such downward displacement of the brain can also result in herniation of the cerebellar tonsils through the foramen magnum, leading to potentially life-threatening conditions.Compression of the brain stem with cerebellar tonsillar herniation can cause depression of the vital centers for respiration and cardiac rhythm control. This could explain the slowed heart rate with maintenance of normal blood pressure that has been observed in patients with intracranial hypotension, which Schaltenbrand has referred to as “vagus pulse.” More severe consequences include altered mental status and coma. Venous engorgement can cause stretching of the vessel walls with rupture of bridging veins, resulting in subdural hematomas that can become chronic if the underlying intracranial hypotension is not properly managed.

MISDIAGNOSIS

SIH headache is often misdiagnosed as a number of other neurologic conditions, such as aseptic meningitis, subarachnoid hemorrhage, subdural hematoma, Chiari type I malformation with cerebellar tonsillar herniation, or secondary to intracranial hypertension. However, further diagnostic testing may help to distinguish SIH from other possible etiologies of the headache. These diagnostic tests include lumbar puncture, CSF analysis, brain and spinal imaging, in addition to consideration of the patient’s history and clinical presentation. Prompt and accurate diagnosis of intracranial hypotension is essential to avoid costly and invasive procedures meant to treat other conditions with which the patient may have been misdiagnosed, as well as to avoid prolonging the process initiated by the underlying condition and thus allowing symptoms to persist despite treatment. The International Headache Society has outlined diagnostic criteria for the headache attributed to spontaneous or idiopathic low CSF pressure. This can aid in the diagnosis of SIH, while decreasing the incidence of misdiagnosis and minimizing the time elapsed before proper treatment is administered.

However, even with the judicious use of these criteria, diagnosis of SIH is still thwarted by an atypical presentation without the classic postural headache. In particular, patients presenting with subdural hematomas may not complain of...
the typical headache associated with SIH as the accumulation of blood from the hematoma compensates for the underlying low intracranial pressure. Karumae et al. reported a case in which a previously healthy 28-year-old man presented with non-traumatic chronic subdural hematomas and underwent drainage of the hematomas with subsequent acute subdural hematoma and worsening of his condition, all because treatment proceeded after SIH was deemed unlikely due to the absence of the postural headache. The authors thus emphasize the importance of considering SIH in an otherwise healthy adult with non-traumatic chronic subdural hematomas and no known risk factors for the development of subdural hematomas. Schievink et al. have also proposed alternative criteria for the diagnosis of SIH in which postural headache is not necessarily a prerequisite.

Lumbar puncture in the setting of intracranial hypotension will reveal a low or absent opening pressure, as well as a sucking sound as the stylet is withdrawn from the needle after penetration of the subarachnoid space. If the intracranial pressure is equal to or less than atmospheric pressure, CSF may fail to flow freely and can be collected by gentle aspiration with a small syringe. If opening pressure is measured at 0-mm H2O with the patient in the lateral recumbent position, then the patient may sit up to allow the fluid to rise in the manometer. Jugular compression and use of the Valsalva maneuver could also assist in provoking a mild rise of the fluid level. Analysis of the CSF can have abnormal findings of elevated protein content and pleocytosis. It is also not uncommon for analysis of CSF to be within normal limits, and so the results of cranial imaging are weighted more heavily in the diagnosis.

ZEROING IN

Schievink has identified five common findings on cranial imaging associated with intracranial hypotension. These findings include subdural fluid collections or hygromas, which is usually a late finding. As mentioned previously, stretching and ultimate rupture of vasculature within the subdural space can result in hematomas. The most common finding is pachymeningeal enhancement on gadolinium-enhanced magnetic resonance imaging (MRI). This enhancement is due to the proliferation of fibrocollagen in the leptomeninges, in the absence of inflammation. Engorgement of venous structures can be visualized on MRI or cerebral angiography. Venous engorgement is the mechanism leading to another common finding, which is pituitary hyperemia with or without pituitary enlargement. Lastly, brain sagging may also be appreciated and can be severe enough to reveal cerebellar tonsillar herniation. Follow-up imaging such as computerized tomography (CT) myelography and radionuclide cisternography can assist in confirming diagnosis and localizing the site of CSF leakage if necessary.

Recent studies have also demonstrated the usefulness of gadolinium-enhanced magnetic resonance myelography in detecting and localizing CSF leaks without having to expose patients to radiation, although this application of gadolinium is still an off-label use. Leaks are usually found in the cervicothoracic junction or along the thoracic spine. Although imaging studies have often uncovered retrosposi fluid collection between the lamina of C1 and C2, this finding is not believed to represent the actual site of leakage but is instead thought to result from the transudate of dilated epidural veins or from fluid that has collected in that area after leaking from the actual leakage site.

Trauma and medical procedures involving dural tears at the skull base have been associated with CSF leakage through the nasal passage or ear structures, referred to as CSF rhinorrhea and otorrhea, respectively. At initial presentation, it may be difficult to differentiate nasal discharge attributed to CSF rhinorrhea from that of respiratory secretions, tears, or blood. Beta-2-transferrin is a protein found exclusively in CSF and perilymph, and thus can be used to detect the presence of CSF in nasal discharge by immunofixation electrophoresis. However, this laboratory test is neither timely nor widely available. The glucose oxidase stick test has been used more frequently, which is quick, easily accessible, and can be performed at the bedside. This test measures glucose concentration as an indicator of CSF in nasal discharge, but it has a low positive predictive value. Glucose could also be detected in the nasal discharge of patients with nasal inflammation or with blood glucose levels greater than 6-mmol/L. Baker et al. have proposed an algorithm for the use of the glucose oxidase stick test at the bedside that optimizes its diagnostic value. Their report states that CSF is more likely to be present in the nasal discharge of patients with suspected CSF leak if the discharge contains glucose without any visible blood, blood glucose level is under 6-mmol/L, and in the absence of symptoms suggestive of an upper respiratory tract infection including sneezing, nasal blockage, cough, sore throat, sputum, or purulent nasal discharge. This test is not meant to definitively diagnose CSF leakage, but rather to help direct further work-up in the context of additionally supportive clinical and diagnostic evaluations. A negative test does not necessarily rule out CSF leakage either, as CSF glucose levels may be low enough to produce indeterminate results in cases of concomitant bacterial meningitis, subarachnoid hemorrhage, CNS tumor, or neurological complications of connective tissue disorders.

Most patients with intracranial hypotension improve spontaneously, with resolution of symptoms following bed rest, sufficient oral fluid intake, caffeine intake, and time. If symptoms persist with conservative management, another treatment method shown to be effective is epidural blood patching, in which the patient’s own blood in the amount of
approximately 10-20mL is used to replace the volume lost from CSF as well as serve as a sealant at the site from which CSF is leaking. Localizing the site of leakage is not necessary for this treatment to work. The blood patch is placed at the thoraco-lumbar junction, followed by placement of the patient in the Trendelenburg position for up to one hour to allow the blood to pass over several spinal segments along the thoracic spine and towards the cervicothoracic junction. Patients with severe signs of post-surgical intracranial hypotension may necessitate immediate treatment with epidural blood patching and placement in the reverse Trendelenburg position, as the defect in those cases are likely localized in the lumbar spine (e.g., following placement of a lumbar drain). Epidural blood patching can be repeated with a larger volume of blood if the initial patch is unsuccessful, with an interval of five days between blood patches. If both attempts at epidural blood patches fail, then it might be necessary to localize the exact site of leakage for a directed epidural blood patch or percutaneous placement of fibrin glue.

If all nonsurgical treatments have still failed to resolve symptoms, then surgical treatment options can be explored. Surgical treatment also requires that the exact site of CSF leakage be known. In cases involving leaking meningeal diverticula, the lesions can be closed off with sutures or with a metal aneurysm clip. Simple holes in the dura can be sealed with sutures or with a pledget of muscle along with gelfoam and fibrin glue. Temporary treatments may be necessary to relieve CSF hypovolemia in patients in critical condition, such as those with impaired level of consciousness, while awaiting surgical correction. Such interim measures include the infusion of saline or artificial CSF intrathecally into the subarachnoid space.

CONCLUSION

Overall, the prognosis of patients with intracranial hypotension is very good, with the majority of patients achieving full recovery following an epidural blood patch if not resolution of the headache spontaneously. There have been some cases of symptom recurrence despite treatment, which could be attributed to persistence of the underlying causative process or residual leak sites undetected by imaging studies and thus left untreated.

A study conducted by Schievink et al.6 in 2005 revealed a better prognosis for those patients with an abnormal MRI than for those with an initially normal MRI. Further and more expansive research is necessary to elucidate the reasons behind these imaging findings and their respective predictive prognostic values, as well as to gain a better understanding of the epidemiology of intracranial hypotension in a larger and more diverse population. In addition, greater awareness of the condition and its associated symptoms would lead to more efficient diagnosis and treatment for those patients who suffer from it. ■