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Pearls & Oy-sters: Cerebral Venous Congestion Associated With Cognitive Decline Treated by Jugular Release

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Abstract:
Cognitive dysfunction is often multifaceted and can be seen across all age groups in medicine. The combination of cognitive decline and increased intracranial pressure may suggest possible anatomical abnormalities. We present a case report from our academic center that describes a young man with new cognitive fatigue and brain fog in the setting of increased venous pressure that resolved with surgical intervention at a site of jugular vein stenosis. We discuss current hypotheses from basic and clinical research related to pathophysiology underlying venous vascular congestion and associated neurological disorders. Further research is warranted to elucidate underlying mechanisms of venous congestion and cognition to better identify therapies and improve quality of life for patients.

Pearls
- Dynamic venography performed with provocative neck maneuvers and measurement of torcular pressure will identify at-risk patients with suspected cerebral venous congestion.
- An elevated cerebral venous pressure gradient by the transverse process of C1 can be reduced by C1 tuberculectomy.
In patients presenting with suspected abnormal intracranial pressure and new cognitive decline, the possibility of cerebral venous congestion (CVC) from stenosis or obstruction should be considered.

Cognitive decline is often irreversible in several neurological conditions; however, symptoms secondary to CVC can be reversed when promptly intervened.

Case Report

A 30-year-old man without prior medical diagnosis presented to the emergency department with new, persistent headache. He described the headache as a pressure-like sensation, worse while standing, associated with gait imbalance, and resolving when supine without moving his head. Over-the-counter medications provided minimal relief of symptoms. One month prior to his presentation, he suffered a ground-level fall from his mountain bike, resulting in minor head trauma without loss of consciousness. He was wearing a helmet during the fall. Three days prior to his presentation, he developed a new, persistent headache while riding his bike. He denied prior history of headaches, blurry vision, or weakness. Review of systems was positive for back and neck pain. His neurological examination was unremarkable, and he was referred to neurology for evaluation of post-concussive headache.

Patient underwent MRI brain with contrast which revealed mild pachymeningeal enhancement. CT myelography was pursued to evaluate cerebrospinal fluid (CSF) leak and revealed dural diverticula bilaterally at T7/8, T12/L1 and L4/5 without definite CSF leak. A 3-site targeted blood and fibrin patch was empirically performed with resolution of headache.

Patient returned to clinic one year later with recurrent symptoms after lifting a heavy object from the floor. MRI-spine with CT-myelogram complex showed multiple dural diverticula throughout the thoracic spine, and an area of curvilinear contrast extravasation along the right T7-T8 neuroforamina, suspicious for CSF leak (Figure 1A-B). He underwent a second blood patch with transient improvement in headache; however, the head pressure was now worse on exertion and head turning. He developed pulsatile tinnitus, visual obscurations, exercise intolerance, and brain fog, which progressed over the following six months. Patient worked as a financial analyst and was functioning at 50% capacity given the brain fog, cognitive slowness, and inattentiveness that worsened while performing arithmetic and critical thinking. His
neurological examination again was normal without evidence of disc edema. Lumbar puncture (LP) revealed opening pressure (OP) of 19 cm H\textsubscript{2}O and he was started on acetazolamide for symptomatic relief of presumed rebound intracranial hypertension-related headache.

Given the number of dural diverticula and the association of CSF pressure elevations with venous stenosis, a provocative maneuver CT venogram was performed. The imaging demonstrated narrowing of the left internal jugular vein (IJV) along the left styloid process with near collapse at the mildly flexed position with mild flexion and rotation of the head to the left as well as moderate right IJV impingement by styloid and transverse process of C1 (Figure 2A-C). Head turning worsened the impingement with moderate suboccipital venous collaterals to the paravertebral and deep cervical venous networks. Venous manometry revealed: (1) torcular pressure (TP) of 16 mmHg with increase to 20 mmHg on head turning to either side; (2) right atrial (RA) pressure was 6 mmHg (reference normal: 4-7 mmHg); and (3) brain-heart gradient (BHG) of venous pressures of 10 mmHg using the torcular as brain baseline and right atrial pressure as cardiac baseline. The gradient across the right IJV was 4 mmHg in neutral position and 8 mmHg in neck rotation.

After several months without relief despite aggressive medical management, patient underwent right C1 tuberculectomy for release of the jugular vein impingement. Three-month follow-up venography demonstrated TP of 7 mmHg, RA pressure of 3 mmHg, and no gradient across either internal jugular vein. Residual impingement of the left IJV was present without gradient. The BHG had dropped from 10 mmHg to 4 mmHg.

Upon three-month follow-up visit, patient reported resolution of cognitive dysfunction, headaches, visual obscurations, exercise intolerance, and near resolution of tinnitus. He returned to full-time work; in contrast, he previously was only able to tolerate four hours per day after the second blood patch.

Discussion

Descriptions of intracranial pressure (ICP) and its hypothesized relationship to arterial and venous blood flow were first published by Alexander Monro in the late 18\textsuperscript{th} century.\textsuperscript{1} He hypothesized that the sum of the volumes of brain, CSF, and intracranial blood is constant, such that an increase in one must result in a decrease in another to maintain equilibrium. This principle has been used in understanding several neurological disorders, specifically idiopathic
intracranial hypertension (IIH), in which treatment is focused on CSF pressure and volume management.

Only recently has an association between cerebral vasculature hemodynamics and cerebral venous hypertension, sometimes referred to as congestion, been reported. Cerebral venous congestion (CVC) is a clinical state of symptoms secondary to relative reduction in venous outflow in the brain. CVC is most often interpreted in the context of IIH, venous hypertension, and venous stenosis. In 1995, King et. al described venous stenosis through venography in IIH. In several case series characterized various rates of intracranial venous narrowing. Transverse sinus narrowing has been reported in as many as 93% of IIH patients. Bilateral transverse flow abnormalities occur in up to 65% of patients and were not seen in age-matched controls. In 2002, Higgins et. al reported in *Lancet* a successful venous sinus stent placement in a woman with intractable IIH symptoms with bilateral transverse sinus stenosis. After dilation of a single transverse sinus, there was reduced pressure gradient and symptomatic relief. Further studies report one-third of patients with IIH and isolated IJV stenosis who undergo venous stenting show resolution of symptoms including brain fog.

Cognitive dysfunction is occasionally noted in patients with ICP abnormalities; however, underlying pathophysiology is unknown. In a prospective case-control study of patients with IIH and controls who underwent neuropsychological testing, patients with IIH performed significantly worse in reaction time and processing speed. These impairments persisted on three-month follow-up despite medical management. Traditional treatment options in IIH include weight loss and acetazolamide, while procedural diversion of CSF with shunts or optic nerve fenestration are typically reserved for medically refractory cases and venous stenting in transverse sinus stenosis. In rare cases, extrinsic compression resulting in venous stenosis have been described, particularly obstruction of the IJV from C1 transverse process, cervical spondylosis, or styloid process. Surgical intervention to relieve obstruction through styloidectomy for management of jugular stenosis in IIH have been explored and can provide symptomatic relief to patients.

Moreover, intracranial dural arteriovenous fistulas (dAVFs) may infrequently manifest as progressive dementia, believed to be the result or contribution of venous hypertension in the cortex or bilateral thalami as part of a thalamic dementia syndrome. In several case-series,
more than half of the patients undergoing dAVF obliteration experienced significant improvement in cognition or complete reversal of dementia-related symptoms at six-month follow-up.\textsuperscript{11}

In the current case report, our patient suffered from venous congestion with TP elevated 10 mmHg from the RA. To date, there are no established reference standards for TP as invasive venous manometry are not typically performed on control patients. Patients with suspected IIH with normal LP OP (<20 mmHg) have measured TP ranges from 7-21 mm Hg.\textsuperscript{12} The cited manuscript further describes a direct 1:1 relationship between venous sinus pressure (most accurately measured at the torcula) and OP, (1 mm Hg increase per 1 cm H\textsubscript{2}O increase, respectively).\textsuperscript{12} We believe there is a connection between the venous system, CSF flow and pressure, and potentially blood-brain barrier (BBB), which most profoundly manifested clinically in our patient’s cognitive decline.

Basic science research is underway to elucidate pathogenic role of venous congestion in the brain resulting in cognitive decline. The current hypothesis within a mouse model of cerebral venous congestion showed distribution in the BBB and longstanding activation of neuroinflammatory-related gene expression as compared to control mice.\textsuperscript{13} After jugular vein ligation, mice showed impaired spatial learning, gait, and cognitive function as well as immunostaining of brain tissue with evidence of microglial activation. Further models have expanded to include venous dysfunction in human aging, specifically related to age-related cerebral white matter hyperintensities and cognitive decline.\textsuperscript{14} The designated venous hypothesis suggest pathologic changes in aging may be, in part, due to progressive degenerative changes in the intracranial venous system - increased venous wall stiffness, loss of compliance, increased pressure environment at the capillary bed, and further disruption of blood-brain barrier.\textsuperscript{15} Understanding vascular changes that may contribute to such deficits in aging as well open therapeutic targets to prevent cognitive decline are warranted.

Cognitive dysfunction is often multifactorial and can be seen across all age groups. This case illustrates a novel cause and a potential therapeutic target for cognitive decline. Further research is needed to elucidate underlying pathophysiology of venous congestion and cognition. Recognizing the potential inter-relationship between cerebral venous congestion, intracranial
hypertension, CSF leaks and cognitive impairment may accelerate diagnosis and treatment in such patients.

**Figure Legends:**

Figure 1. (A) Small curvilinear focus of contrast extravasation along the right nerve root at T7-T8, suspicious for CSF leak. (B) Dural diverticula noted throughout the thoracic spine, most notable at T11-T12.

![Figure 1](image1.png)

Figure 2: (A) Sagittal view demonstrating compression of the IJV at C1, compressed between the styloid process and the lateral mass of C1. (B) Coronal View (C) Sagittal view of the L IJV nearly compressed by the left styloid process and the lateral mass of C1.

![Figure 2](image2.png)
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1. Monro A. Observations on the structure and functions of the nervous system. 1783
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