PRESSURE AND HEADACHE RELATIONSHIPS

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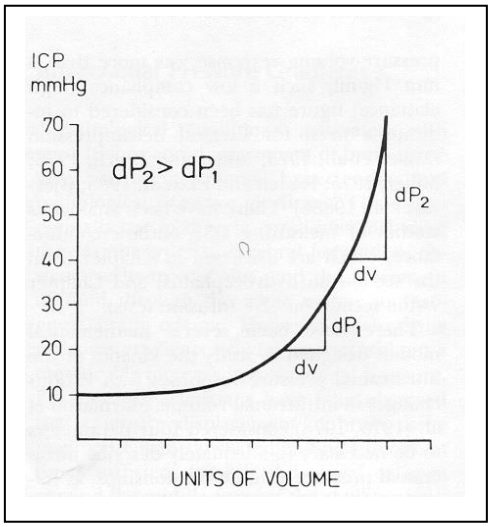
What is normal CSF pressure?
The generally-accepted normal range for CSF pressure, as measured by lumbar puncture is 18-200 mm CSF in adults. Some studies in patients with idiopathic intracranial hypertension (IIH) have found a modest effect of BMI on opening pressure (Randhawa).

Normative values in children have been studied in more detail than in adults, ranging from 115-280 cm CSF (Avery 2010). Factors influencing CSF pressure during a lumbar puncture in children include moderate-to-deep sedation (increases by an average 35 mm), body mass index (30 mm for every 10 BMI units above normal for age), and perhaps the length of the needle (3.5 vs. 1.5 inches). There was no effect of leg position (flexed vs. relaxed) or age in children (Avery 2014).

CSF pressure varies widely throughout the day. A Valsalva maneuver can double the CSF pressure during an LP (Neville). Continuous CSF pressure monitoring in patients with IIH revealed pressures from 50-500 mm CSF (Gucer). Values up to 980 mm CSF were found in a patient with a frontal lobe glioma (Addison). As these patients were likely supine in bed when the measurements were taken, one can imagine that the range of CSF pressure in an active individual is wide.

The relationship between CSF pressure and volume is exponential, not linear. As intracranial pressure rises, a small increase in volume causes a larger and larger increase in pressure.



What is abnormal CSF pressure?
Abnormal CSF pressure in adults is greater than 250 mm CSF. A study of patients with acute (n=116) and chronic (n=18) IIH compared the LP opening pressure normal obese controls (n=41) and normal non-obese controls (n=15) (Corbett). Patients with acute IIH all had opening pressures $\geq$200 mm CSF. Obese normal controls had pressures <250 mm CSF and only one non-obese control had an opening pressure between 240-249. One patient with chronic IIH had 2 LPs, one of which showed a normal OP and the other was elevated. Most of the IIH patients were women and most of the controls were men. Values between 200-249 were a "gray" zone that could not reliable distinguish between normal and IIH patients. Another study evaluated 242 adults with no evidence of increased ICP clinically (Whitely). The mean opening pressure was 170 mm CSF and the reference range was 100-250 mm CSF.

The International Classification of Headache Disorders (ICHD-3 beta) criteria for headache caused by spontaneous intracranial hypotension (SIH) specify an opening pressure <60 mm of CSF for diagnosis. However, one study showed that only 1/3 of patients fell into that range and most patients with SIH had normal LP opening pressures (Kranz). "SIH" is somewhat of a misnomer, as the disorder is primarily one of low CSF volume.

How do high and low pressure cause headache?
The pain sensitive structure in the brain are the blood vessels and the meninges. In the case of high pressure, headaches may arise from a structural change related to the compressive effect of the CSF on these structures. Venous hypertension is associated with IIH, often with venous sinus stenosis, raising the possibility that vascular compression of large cerebral vessels is the mechanism of the headache in some patients.

The headaches of SIH are thought to be cause by dural and nerve traction that results from brain sag. Presumably, this can occur even with minimal downward excursions of the brain, as patients with normal brain imaging have severe headaches from CSF leaks. There is also a theory that SIH involves negative pressure within the inferior vena cava, resulting in more CSF absorption into the epidural space and veins; thus the vasculature may also be involved (Rahman).

Why do some people get a headache with ICP disorders and others don't?
Headache is not present 100% of the time in either IIH or SIH. It is uncertain why the threshold for developing headaches in the presence of high or low CSF pressure varies so much among individuals. Although headache is the most common symptom of IIH, patients may also come to medical attention because of neck or back pain, visual symptoms, pulsatile tinnitus or asymptomatic papilledema detected on a routine eye exam. In the Idiopathic Intracranial Hypertension Treatment Trial, which studied patients with mild visual field loss who all had papilledema, 129 of 165 participants had headaches at the baseline visit. There was no correlation between headache disability, as measured by HIT-6, at either baseline or after the study intervention at the 6 month (primary outcome) visit (Friedman 2017). All but 4 patients in the IIHTT were women and 41% had a history of migraine, which is over twice the expected prevalence of migraine in the general population. Perhaps the brain physiology associated with migraine renders these patients more susceptible to developing headaches in the setting of increased intracranial pressure.

The prevalence of headache absence in SIH is unknown, as asymptomatic patients are not reported in the literature. Other symptoms and signs of SIH include loss or alteration in consciousness, movement disorders (Parkinsonism and hyperkinetic syndromes), tinnitus and perturbations in hearing, galactorrhea, quadriplegia, radiculopathy and visual symptoms. It is uncertain how often these occur without headache. Anecdotally, there are asymptomatic patients with typical imaging findings of SIH (i.e., meningeal enhancement, brain sag).

What perpetuates the headache after treated intracranial hypertension?
Headaches persist in about two-thirds of patients following otherwise successful treatment of IIH (Friedman, Yri). The reason is uncertain. Elevated CSF pressure might lead to persistent and chronic trigeminal activation and irritation that persists even after CSF pressure is normalized.

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