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Cerebrospinal Fluid Production and Volume

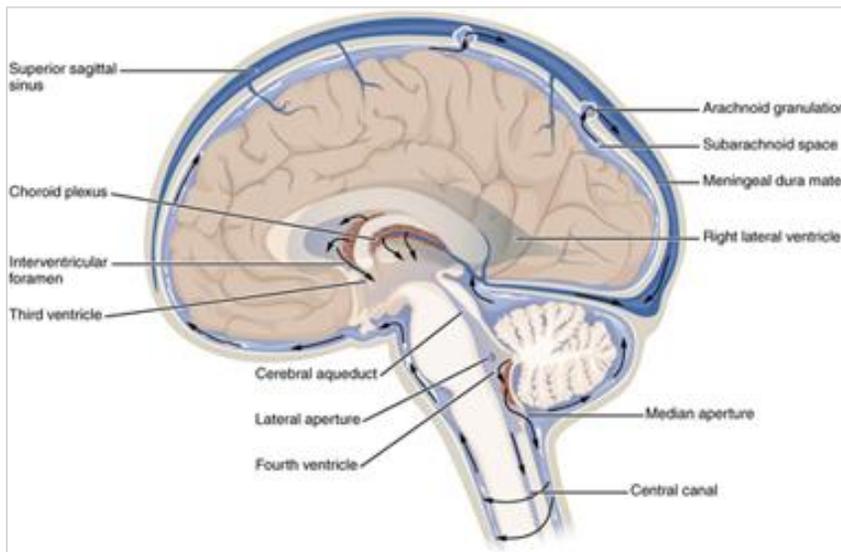


Figure 1: CSF is produced in the choroid plexuses of the ventricles of the brain. [Image: OpenStax / Wikipedia]

The brain and spine are surrounded by clear, colourless fluid known as cerebrospinal fluid (CSF). It acts as a cushion and buffer, bathing the brain and spine and providing basic mechanical and immunological protection.

In an average, healthy adult, about 125-150ml of CSF is present at any one time. CSF is contained within the meninges and it is continuously produced and reabsorbed at a rate of about 0.35 ml/min. The brain produces roughly 500 ml of CSF per day¹.

Where a dural puncture or tear is present, CSF leaks out of the meninges and the volume of CSF drops. It is this loss of fluid volume that produces many of the symptoms of a CSF leak and can result in a low opening pressure, when measured by lumbar puncture (or through intracranial pressure monitoring).

Not all CSF leaks result in low opening pressure and, as such, an opening pressure within 'normal' range cannot be used to definitively rule out a CSF leak². The dismissal of CSF leak as a diagnosis on normal opening pressure alone should be queried.

Opening Pressure Range

What is considered to be within the 'normal range' for CSF opening pressure varies noticeably between sources, as well as medical professionals. The physiology of each patient is also different, so too their 'normal' pressure prior to suffering a CSF leak; in reality, it is impossible to state precisely what 'normal' should be for any given person. This can be a problem for correct CSF leak diagnosis.

¹ http://www.neurosurg.cam.ac.uk/pages/brainphys/01-Physics_of_cerebrospinal_fluid_circulation.pdf

² <https://www.ncbi.nlm.nih.gov/pubmed/23808630>

However, when measured in left lateral decubitus position (lying on left side), a common definition of 'normal' is an opening pressure range of 7-18 cmH₂O in adults³, although some also consider the normal range as being 10-20 cmH₂O⁴ or 5-25 cmH₂O⁵.

It is, however, widely agreed that a pressure reading of >25 cmH₂O or <5 cmH₂O is not normal, and would be abnormally high or low respectively. High pressure is known as intracranial **hypertension**, while low pressure is known as intracranial **hypotension**.

False Positives/Negatives

A number of factors may influence opening pressure and result in an inaccurate or misleading reading being taken. Lumbar punctures are normally carried out with the patient lying on their side with their head supported, and that position is what most opening pressure ranges relate to.

If a patient is sitting up, for example, opening pressure readings will almost certainly be higher. Similarly, if a patient is tense, straining or performing a valsalva manoeuvre, or pulling their knees up excessively tightly towards their chest, it may increase pressure of the cerebrospinal fluid within the thecal sac.

If a patient hyperventilates, this can cause the opening pressure to be lower. Patients who are dehydrated or hypotensive may also have a decreased opening pressure⁶. This is not a false negative per se, because it is a true low, but is likely to be misleading.

Measuring CSF Pressure

The pressure at which the cerebrospinal fluid is held within the body, also known as intracranial pressure (ICP) when measured within the skull, is typically measured in two different ways. A pressure sensor can be introduced into the skull to directly measure ICP (normally over a period of hours or days), known as ICP monitoring, or CSF opening pressure can be monitored on lumbar puncture.

Neither approach uses the same unit of measurement, which can cause some confusion, nor is pressure within the skull always identical to pressure within the spine. ICP monitoring is normally carried out over a period of hours and looks at fluctuations and trends during that period, whereas opening pressure is single reading and a snapshot in time.

The measurement of ICP is normally made in mmHg (millimetres of mercury) and opening pressure on lumbar puncture is normally measured in cmH₂O (centimetres of water), or less commonly in mmH₂O (millimetres of water).

Where lumbar puncture is performed, in order to reduce the risk of post-dural puncture headache and persistent CSF leaks, non-cutting needles (such as a Gertie Marx spinal needle) should be used whenever possible⁷.

The type of needle to be used should always be queried with the doctor performing the procedure, as many practitioners - in particular those who carry out the procedure infrequently - are still in the outmoded habit of using cutting needles (such as BD Quincke spinal needle). Similarly, the stylet should be replaced prior to the needle being withdrawn from the thecal sac⁸.



Figure 2: Measuring opening pressure by lumbar puncture brain [Creative Commons]

³ Reichman E F, Polglaze K, Euerle B. Neurological and Neurosurgical Procedures: Lumbar Puncture. In: *Emergency Medicine Procedures*. McGraw Hill; 2013:747-761.

⁴ <http://emedicine.medscape.com/article/2172226-overview>

⁵ Lee S, Lueck C. Cerebrospinal fluid pressure in adults. *J Neuroophthalmol*. 2014;34(3):278-283. [PubMed]

⁶ Seehusen D, Reeves M, Fomin D. Cerebrospinal fluid analysis. *Am Fam Physician*. 2003;68(6):1103-1108. [PubMed]

⁷ [http://www.clineu-journal.com/article/S0303-8467\(14\)00496-X/fulltext](http://www.clineu-journal.com/article/S0303-8467(14)00496-X/fulltext)

⁸ <http://emj.bmj.com/content/22/1/46.full>

Questions? Need more information?

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Pressure Conversion Table

The following table provides at-a-glance conversion between the units of measurement used in opening pressure (cmH₂O or mmH₂O) and intracranial pressure (mmHg) readings **while a patient is lying down**. Mean normal intracranial pressure whilst standing is -10mmHg (max. -15mmHg)⁹. Colour-coding is provided to give a rough indication of pressure ranges.

Millimetre of Mercury (mmHg)	Centimetre of Water (cmH ₂ O)	Millimetre of Water (mmH ₂ O)
0	0	0
0.7	1	10
1.5	2	20
2.2	3	30
2.9	4	40
3.7	5	50
4.4	6	60
5.1	7	70
5.9	8	80
6.6	9	90
7.4	10	100
8.1	11	110
8.8	12	120
9.6	13	130
10.3	14	140
11.0	15	150
11.8	16	160
12.5	17	170
13.2	18	180
14.0	19	190
14.7	20	200
15.4	21	210
16.2	22	220
16.9	23	230
17.7	24	240
18.4	25	250
19.1	26	260
19.9	27	270
20.6	28	280
21.3	29	290
22.0	30	300

Pressure Range Key

Low Pressure	Normal Pressure	Moderately High Pressure	High Pressure
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*This key is provided as a simple ready reckoner only and is based on a broad average of published ranges for low, normal and high pressure. Physiology and CSF dynamics differ between individuals and what may be unremarkable for one person may not be for another. You must always seek the advice of your medical team to determine the nature and implications of your intracranial or opening pressure readings.

Further Information

For more information on CSF leaks and intracranial hypotension, including causes, symptoms, diagnosis and treatment, or to download copies of our other factsheets, please visit our website: www.csfleak.info

⁹ <http://jnnpbeta.bmj.com/content/75/6/813.full>

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