ORAL PRESENTATIONS

The influence of body position on cerebrospinal fluid circulation

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Background

Cerebrospinal fluid (CSF) circulation consists of two components, a net flow and a pulsatile flow. CSF is generally believed to be produced through the ventricular choroid plexuses and absorbed in sites such as the subarachnoid granulations and nerve roots, contributing to the net flow. The pulsatile driving forces include cardiac vascular pulsation, respiration and muscular contraction.[1] Measuring CSF flow in the upright posture is important because we spend most of our lifetime upright.

Methods

Thirty asymptomatic volunteers (age: 22-72; 9 males, 21 females) were scanned in the upright seated and supine position on a 0.6 T multi-position MRI scanner (Fonar, New York, USA). CSF flow and spinal cord pulsation were imaged and quantified at the axial mid-C2 level with cine phase-contrast MRI.

Results

In the upright posture, heart rate increased by 10%, and peak CSF diastolic flow decreased by 43% compared to the supine posture.[2] In addition, the oscillatory volume of CSF exchanged between the spine and cranium decreased by 37% when going from supine to upright posture, consistent with a previous study.[3] This could mean that the amount of time spent in different postures as we age may affect the efficiency of glymphatic brain waste clearance and development of neurodegenerative diseases.

A less studied but diagnostically important aspect of CSF flow is the concomitant pulsation of spinal cord and central nervous system (CNS) tissue. For example, it is found that in Alzheimer's Disease patients, the spinal cord at mid-C2 is pulsating much more in the mid to high frequency range (4 to 8 Hz) compared to normal older people in the supine posture. In the normal population, the mid-C2 spinal cord pulsates much less in the upright posture, with a 40% reduction of peak systolic velocity compared to the supine posture.

Other postural differences include the more prominent appearance of nerve roots in the supine posture, shift of venous outflow from jugular veins to epidural/smaller veins, and the slimming of the neck when upright.

It is also found that CSF flow is much more sensitive to aging in the upright than in the supine position. More specifically, as we age, heart rate change between postures diminishes and the upright peak systolic/peak-to-peak pressure gradient decreases. Since studies have shown that meditation can slow down brain aging, it would be beneficial to study its effect on CSF flow and the process of brain waste production and clearance.

Conclusions

Besides delineating the many significant postural differences in CSF circulation, multi-position CSF imaging is also valuable in diagnosing various diseases such as Chiari malformation,[4] Ehlers-Danlos syndrome and tethered cord syndrome in the lumbar spine. Often pathology that is not evident in the traditional supine imaging position can be visualized in other patient positions.

Finally, a seminal study[5] in rodents found that glymphatic transport is most efficient in the lateral recumbent position compared to supine or prone position, which concluded that posture must be considered in future diagnostic imaging procedures to assess CSF – interstitial fluid (ISF) transport in humans.

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Received for publication: 26 September 2022.
Accepted for publication: 14 October 2022.

Veins and Lymphatics 2022; 11:10947
doi:10.4081/vl.2022.10947

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