Key Points

1. The flow of CSF between the brain and spine is driven by the beating heart pumping blood into the brain
2. The resulting movement/pulsation of the cerebellar tonsils is thought to lead to syrinx formation in some Chiari patients
3. Based on this, researchers hypothesized that patients with Chiari would show more tonsillar motion on MRI than healthy controls
4. While they did find this, the differences were very small and the total movement was less than 1mm
5. This contradicts reports based on intraoperative ultrasound which show dynamic movement of the tonsils
6. The reason for this discrepancy is not clear

Definitions

cardiac cycle - the heartbeat

cine MRI - type of MRI which can play the images like a movie and show motion

intraoperative ultrasound - type of imaging technology which uses sound waves to create images and show motion; surgeons sometimes use it during decompression surgery

cerebellar tonsils - portion of the cerebellum located at the bottom, so named because of their shape

cerebrospinal fluid (CSF) - clear liquid in the brain and spinal cord, acts as a shock absorber

Chiari malformation I - condition where the cerebellar tonsils are displaced out of the skull area into the spinal area, causing compression of brain tissue and disruption of CSF flow

syringomyelia - condition where a fluid filled cyst forms in the spinal cord

MRI Shows Little Tonsil Movement

March 31st, 2009 -- Long time readers of Chiari & Syringomyelia News likely recall the connection between CSF and blood flow. Specifically, that the flow of CSF between the brain and spinal areas is driven by the heart pumping blood into the brain and back out again. As you think about this cycle - heart, blood, CSF - it is easy to imagine the cerebellar tonsils pulsing downward with each heart beat.

Indeed, this pulsing motion of the tonsils is the basis for one of the leading theories on syrinx formation, the piston theory. This theory, developed out of work at the National Institutes of Health (NIH), holds that the piston-like motion of the tonsils drives a pressure wave of CSF down the spinal canal, which in turn forces CSF into the spine and leads to a syrinx.

Like most theories, the piston theory does not necessarily explain everything and has both its supporters and critics. Critics have point out that for a syrinx to expand, the pressure inside the cord must be higher than the pressure outside the cord, which means that it would be impossible for the fluid to enter the cord in the first place. However, mathematical and engineering analyses have shown that the pressure environment created by the cardiac cycle is complex and may produce conditions favorable for fluid to enter the cord and form a syrinx.

Regardless, it is interesting to think about the dynamic nature of the cerebellar tonsils, and video of a decompression surgery highlights this in a dramatic way, as the tonsils can be seen pulsating. Interestingly, though, a recent publication in the American Journal of Neuroradiology (Cousins & Haughton) found very little movement of the cerebellar tonsils using MRI.

Specifically, the researchers -from the University of Wisconsin - had theorized that patients with Chiari would show more tonsillar movement driven by the heartbeat than healthy controls, and that patients with Chiari and syringomyelia would exhibit even greater movement. The researchers used a specific type of cine MRI to capture the motion of the cerebellar tonsils in 7 Chiari patients, 4 Chiari and syringomyelia patients, and 6 healthy patients. They then used two different techniques to measure the peak movement of the tonsils during the cardiac cycle.

Using these techniques, they did find that there was slightly more movement in Chiari patients than in the healthy controls (Figure 1), but the differences were less than a millimeter. In fact, the total movement of the tonsils, using the MRI technique, was less than a millimeter in all cases. Since the differences were small and there were only a few cases, the researchers were unable to establish if the variations between the Chiari patients and the healthy controls were statistically significant.

What is interesting however, is that the MRI shows very little tonsil movement, both in this study and a previous research publication, yet ultrasound during decompression surgery shows much more dynamic movement of the cerebellar tonsils, and surgeons report very dynamic movement of the tonsils. According to the authors, it is not clear if this discrepancy is due to limitations of the MRI technique or because removing bone during the decompression allows for more movement.

Figure 1: Avg. Tonsillar Movement During The Cardiac Cycle (mm)

Healthy Controls	.43mm
Chiari Only	.50mm
Chiari & Syringo	.61mm

Note: There were not enough subjects to determine if the differences between groups is statistically significant

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Source

Motion of the Cerebellar Tonsils in the Foramen Magnum during the Cardiac Cycle. Cousins J, Haughton V. AJNR Am J Neuroradiol. 2009 Mar 11. [Epub ahead of print]