Key Points

1. The clinical use of phase contrast MRI to evaluate CSF flow in Chiari patients is becoming more common
2. However, the quantitative measurement of CSF for research purposes is more difficult
3. CSF measurements tend to vary among individuals and are highly dependent upon the method used to measure
4. Previous research has shown, however, that peak CSF velocity across the foramen magnum is elevated in people with Chiari
5. This study looked at whether the peak CSF velocity changes as people age
6. Compared 10 health children with 10 healthy adults
7. Found that children had significantly higher peak CSF velocities than adults
8. This peak value trends down as we age, but levels out by about 30
9. Highlights the need for normal comparative data if CSF velocity is to be used to evaluate Chiari

Definitions

cine MRI - type of MRI which can show CSF flow, also known as phase contrast MRI

diastolic - referring to the part of the heart cycle where the heart muscles relax and the heart fills with blood

flow - the amount of a fluid which moves across a space in a given amount of time; for example one milliliter per second

foramen magnum - opening at the bottom of the skull where the brain and spinal cord meet

phase contrast MRI - cine MRI

systolic - referring to the part of

CSF Velocity Changes With Age

February 20, 2006 -- Cerebrospinal fluid (CSF), the clear liquid which circulates around the brain and spinal cord, is a key player in the Chiari saga. Driven by the cardiac cycle, in a healthy person CSF flows freely from the skull area to the spine area across the foramen magnum and back. However, for people with Chiari, the herniated tonsils tend to block the foramen magnum opening and obstruct the natural flow of CSF. It is believed that this disruption of CSF flow can both lead to symptoms and, in some people, the development of a syrinx in the spine.

Given that Chiari blocks CSF flow, it seems logical that looking at the flow of CSF around the tonsils and across the foramen magnum would be a good way to diagnose Chiari. Indeed, phase contrast MRI, which is able to show the speed and flow of spinal fluid, is becoming an almost standard evaluation tool among many Chiari practitioners.

Even with its growing adoption, some neurosurgeons remain skeptical of the clinical value that phase contrast MRI can provide. This publication has been told privately by several prominent neurosurgeons that they are not yet convinced of its value. One surgeon's point of view was that it was useful for borderline cases, but not necessary for many others that either obviously needed surgery, or obviously didn't.

On the research front, phase contrast MRI has been used - with mixed results - to actually quantify characteristics of CSF flow in Chiari patients in hopes of providing objective criteria for diagnosis or surgical success. The quantitative measurement of CSF flow can be difficult because results tend to vary among individuals and are highly dependent upon the specific measurement technique used.

Despite the difficulties, research has shown (see Related Articles) that the peak CSF velocity - meaning how fast it is moving - is elevated in people with Chiari. One way to visualize this is to think of partially blocking the end of a hose with your thumb. When the end of the hose is not blocked, the water trickles out at slow speed, but if you make the opening smaller by blocking it with your thumb, the water comes shooting out at a higher speed. Thus, when the cerebellar tonsils block the opening - the foramen magnum - the CSF comes across at a higher speed.

While this is an intriguing discovery, since CSF flow varies among individuals, if a quantitative measurement of CSF - like peak velocity - is to be used for diagnosis, it is important to understand what a "normal" value for CSF velocity is. A recent study by Iskandar and Haughton - who published the work showing that CSF velocity is elevated with Chiari - begins to do just that, but also shows that it may not be an easy task.

The study, published in the December, 2005 issue of the Journal of Neurosurgery, compared the peak CSF velocity across the foramen magnum of 10 healthy children (age 3-16) with that of 10 healthy adults (ages 21-61) and found that this value changes significantly as we age. Because children need to be sedated for an MRI, the researchers recruited children who were already undergoing an MRI for separate reasons, but who they believed would not have any CSF disruptions. They also recruited 10 healthy adults, and both groups were evaluated using phase contrast MRI to measure how fast their CSF moved.

The researchers found that the velocity of CSF was significantly slower in the adults as compared to the children (see Table 1). The pediatric group averaged 6.9 cm/s and 6.1 cm/s (for the systolic and diastolic phases of the heart cycle), while the adults averaged only 2.4 cm/s and 2.8 cm/s.

The results were even more interesting when the authors plotted them graphically (see Figure 2, below). When analyzed this way, it becomes clear that there is a natural trend whereby CSF speed slows as we age. In fact, this study shows there is a steep drop-off between the first decade of life and the second. After this, the drop-off flattens and there is little change by the time we are 30, although it is important to note there is still wide variation among these healthy individuals at every age range.

It appears that for a quantitative value, such as peak CSF velocity, to be really useful normal values need to be established for all ages. This would require many, many more subjects, but because of the sedation necessary, this becomes extremely difficult with children. However, there is still a critical need for more objective methods to diagnose Chiari and establish the success of surgery, so any step in that direction is a good thing.

Figure 1
Average Peak Systolic & Diastolic CSF Velocity, Pediatric vs Adult

Age Group	Systolic Peak Velocity (cm/s)	Diastolic Peak Velocity (cm/s)
Pediatric (3-16 yrs)	6.9	6.1

the heart cycle where the heart muscles contract, forcing blood into the vessels

velocity - how far something travels in a given amount of time; for example miles per hour, or centimeters per second

Common Chiari Terms

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

cerebellum - part of the brain located at the bottom of the skull, near the opening to the spinal area; important for muscle control, movement, and balance

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

decompression surgery - general term used for any of several surgical techniques employed to create more space around a Chiari malformation and to relieve compression

MRI - magnetic resonance imaging; large device which uses strong magnetic fields to produce images of soft tissue inside the human body

syringomyelia (SM) - neurological condition where a fluid filled cyst forms in the spinal cord

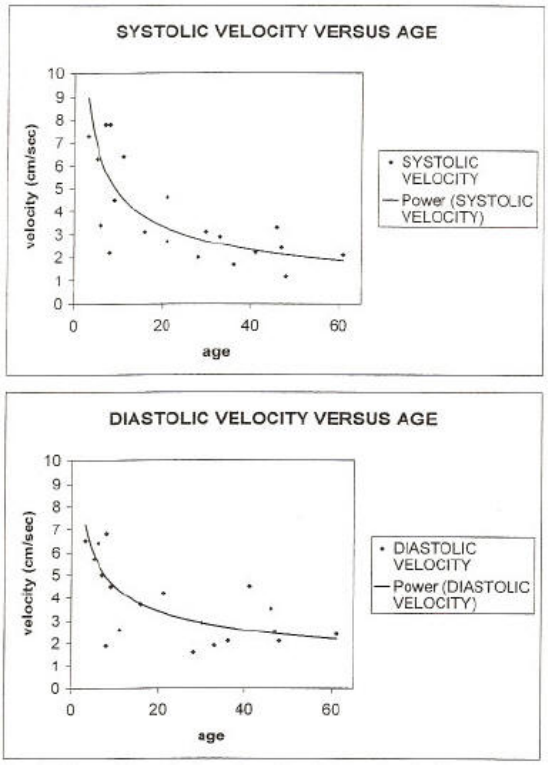
syrinx - fluid filled cyst in the spinal cord

Source

Source: Iskandar BJ, Haughton V. Age-related variations in peak cerebrospinal fluid velocities in the foramen magnum. J Neurosurg. 2005 Dec;103(6 Suppl):508-11.

Adult (21-61 yrs)	2.4	2.8

Figure 2
Peak Systolic & Diastolic CSF Velocity vs Age



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