Key Points

1. Chiari malformation blocks the normal flow of CSF from the brain to spine region and back
2. Researchers and doctors have used phase contrast MRI to measure CSF flow for several years
3. Research results on CSF flow have been mixed and have had trouble linking results to actual clinical outcomes
4. SPAMM is another MRI technique which can be used to measure CSF velocity
5. Study used SPAMM to measure CSF flow above and below the cerebellum on healthy people and Chiari patients before and after surgery
6. Found that a 20% improvement in the total flow in the cervical region consistently predicted headache improvement after surgery
7. Also found that the lack of CSF flow inside a syrinx after surgery predicted motor and sensory improvement
8. Not clear from one small study if SPAMM is better than phase contrast MRI

Definitions

anterior - towards the front

cisterna magna - CSF filled space below the cerebellum

phase contrast MRI - MRI technique which can quantify CSF velocity

pons - part of the brainstem

posterior - towards the back

prepontine - above the pons

SPAMM - spatial modulation of magnetization; MRI technique which allows for the measurement of movement, such as CSF velocity

velocity - how quickly something

Total CSF Flow May Predict Surgical Outcome

November 15, 2005 -- There is no doubt that a Chiari malformation block the normal flow of cerebrospinal fluid (CSF) between the brain and spine regions. This blockage is believed to cause many symptoms and is cited as the primary cause of syrinx formation in nearly every theory. For several years now, doctors have used a type of MRI, known as phase contrast or cine, to qualitatively evaluate CSF flow in some Chiari patients.

However, research efforts to quantify the velocity and flow of CSF in the cranio-spinal area and link the results to symptoms and surgical outcomes has produced mixed results. Measurements vary depending on where and how they are taken. Some researchers have shown that while the overall flow of CSF is blocked, this blockage actually creates high speed jets of fluid in the region. Others have focused on the change in average velocity or flow before and after surgery and tried to link them to specific symptom recovery.

In a recent paper posted electronically in Acta Neurochirurgica, Dr. Sakas, a neurosurgeon at the University of Athens in Greece, along with several colleagues, presented their results in using a different MRI technique, known as SPAMM, to measure CSF flow in the region. The research team believes that SPAMM (spatial modulation of magnetization) is more accurate than phase-contrast MRI because the phase-contrast technique is inherently noisy, which can introduce errors in measurement.

The SPAMM technique manipulates the magnetic signals to essentially create black stripes across a standard MRI image (see Figure 1). Any displacement of one of the stripes represents movement of the tissue - or in this case CSF - beneath the stripe. The velocity of that movement is calculated by measuring the displacement of the stripe and dividing that distance by the time it took to acquire that image.

Dr. Sakas utilized SPAMM on 15 Chiari patients (10 of whom also had syrinxes) and a group of healthy controls. Eight of the Chiari patients were randomly selected to have SPAMM imaging both before and after surgery (Group A). The other seven (Group B) were evaluated after surgery only, and were selected because their symptoms did not improve. The SPAMM images were used to measure CSF flow in three locations: above the Chiari block (what the authors call prepontine), in the front part of the cervical area below the block, and in the back part of the cervical area at the same level.

To link the CSF analysis with clinical outcome, the Chiari patients were evaluated in 4 symptoms areas: headache, limb weakness, limb sensations, and balance. Headaches were considered improved if their frequency was reduced by 70% and their intensity was reduced such that patients did not have to stop activities because of them. Weakness was graded on a 1 to 5 scale, and balance was determined with walking tests. Sensation was evaluated using pinprick, light touch, and temperature. Patients were evaluated by three different doctors who were not aware of the patient's clinical status.

Before surgery, the Group A patients had markedly lower CSF velocity than the healthy controls (see Table 1), especially in the posterior region, behind the cerebellum blockage. After surgery, the average CSF velocity was dramatically higher in the front region, and had improved somewhat in the back region. When the researchers looked at the CSF numbers compared to headaches, they found that a 20% increase in the total flow in the cervical region (front plus back) consistently coincided with headache improvement. Specifically, one year after surgery the headaches had improved in 5 of the 8 patients in Group A. All five of these patients showed a total CSF velocity improvement of at least 20%.

In terms of the strength and sensory symptoms, 6 of the 8 Group A patients had these types of symptoms prior to surgery and 4 of them improved postoperatively. However, the researchers found that this improvement was not linked as much to the CSF velocity changing as it was to the lack of CSF movement in a syrinx itself after surgery. In other words, before surgery, the SPAMM MRI's showed CSF pulsations inside the syrinxes of all these patients. After surgery, there was no CSF movement in the syrinxes of those who improved. In contrast, in the two patients who did not improve (with strength and sensory symptoms), the movement of CSF inside the syrinx was still evident after surgery.

Not surprisingly, the patients in Group B, who did not improve after surgery, continued to show significant blockage, both in the front and back cervical measurements. In thinking about the two groups, it is interesting how the flow of CSF behind the blockage did not return to anywhere near normal, yet there was still symptom improvement.

[**Ed. Note:** This reminds me of three interesting objects I have in my office. Dr. Frank Loth, a bioengineer at UIC, created plastic representations of the amount of CSF flow around the cranio-cervical junction in a healthy person and in a Chiari patient before and after surgery. The plastic models are based on real MRI data from a real person and were created using a rapid prototype machine. In looking at the models, it is amazing how little the

moves; distance per time

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

craniectomy - surgical technique where part of the skull is removed

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

dura - thick outer layer of the covering of the brain and spinal cord

duraplasty - surgical technique where the dura is opened and expanded by sewing a patch into it

laminectomy - surgical technique where part of a vertebra is removed

magnetic resonance imaging (MRI) - diagnostic device which uses a strong magnetic field to create images of the body's internal parts

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

syrinx - fluid filled cyst in the spinal cord

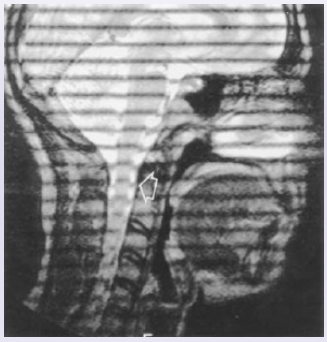
Source

Sakas DE, Korfias SI, Wayte SC, Beale DJ, Papapetrou KP, Stranjalis GS, Whittaker KW, Whitwell HL. Chiari malformation: CSF flow dynamics in the craniocervical junction and syrinx. Acta Neurochir (Wien). 2005 Oct 17; [Epub ahead of print]

amount of CSF flow increased after surgery in the Chiari patient, yet their symptoms improved. As a Chiari patient, one has to wonder what it would feel like to truly have unobstructed CSF flow.]

Clearly, the evidence presented in this study, while very interesting, is not sufficient to say whether SPAMM is a better technique than phase-contrast MRI. A study directly comparing the quantitative measurements might reveal whether there is a difference between the two and which one is superior..

Figure 1
Sample SPAMM MRI Image



Note: Velocity is calculated by measuring the displacement of the black strips over a given area and then dividing by the amount of time it took to acquire that image.

Table 2
Group A Avg. CSF Velocities vs Normal Controls

	Normal	CM Pre Surgery	CM Post-Surgery
Prepontine	2.4	1.5	1.8
Front cervical	2.8	2.1	4.2
Back cervical	2.4	0.5	0.7

Note: All values in cm/s.

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