Key Points

1. There are many variations and open questions regarding the technique of Chiari decompression
2. Dr. Milhorat has performed hundreds of Chiari surgeries
3. Color Doppler Ulstrasound (CDU) was adapted to look at CSF flow
4. CDU was used to guide surgery - and tailor to individual patients - in over 300 cases
5. Quantitative guides were developed for the CSF flow and other parameters
6. Comparative clinical outcome data has not yet been published

Definitions

arachnoid - thin, web-like middle layer covering the brain and spinal cord

autologous - derived, or taken, from a person's own body

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 - 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

cisterna magna - CSF filled space below the cerebellum

Color Doppler Ultrasound (CDU) - type of ultrasound which can detect flow of blood and CSF

dura - thick outer layer covering the brain and spinal cord

duraplasty - surgical procedure where a patch is sewn into the dura

graft - material, or tissue, surgically implanted into a body

Using Ultrasound To Make Surgery Patient Specific

As has been reported several times in this publication, there are many variations to a Chiari decompression surgery with very little data on which techniques are better than others. Currently, surgeons tend to use their own experiences with what works and what doesn't to develop the techniques they are most comfortable with. Open questions about the overall surgery include: how much bone from the skull to remove, when to perform a laminectomy, whether to open the dura completely, whether to open the arachnoid and do an 'internal decompression', whether to shrink or remove the cerebellar tonsils, what type of dural graft material to use, and whether to cover the skull opening.

Despite the fact that decompression surgery is described as technically simple by most neurosurgeons, with this many open questions about the details, variation among surgeons is inevitable and a surgeon's own experiences will play a large role. In the October, 2003 issue of the journal Neurosurgery, the surgeon with perhaps the most Chiari experience, Dr. Thomas Milhorat, weighs in on the technique he and his colleague, Dr. Paolo Bolognese, have used for the last couple of years in treating their patients.

Since 1999, Dr. Milhorat - who founded the Chiari Institute in Long Island - and Dr. Bolognese have used an imaging technology known as color Doppler ultrasound (CDU) to guide their in-surgery decision making in over 300 surgeries. Not only is the CDU capable of helping them identify anatomical features to determine the extent of decompression required, but they have adapted the technology - widely used in cardiac blood flow studies - to measure CSF flow as well. In using the imaging device on such a large number of patients, they have also been able to quantify some of the end goals of the decompression surgery, namely the CSF flow velocity at the cranio-spinal juncture and the amount of space required around the cerebellum.

During the three year period, the surgeons used CDU to help guide their surgical decisions during 315 operations. All patients had demonstrable Chiari malformations and were evaluated with MRI and cine MRI both before and after surgery. The CDU was first used to guide how much bone to remove during the craniectomy. The surgeons started with a small opening and would increase the size a bit at a time until it exposed the compressed area. The amount of bone removed was in general 3.5cm by 3.5cm.

Next a decision was made whether to perform a laminectomy based on the extent of the tonsillar herniation and the length of the required dural incision. Interestingly, the surgeons noted that in many cases, the CDU showed the lower tip of the tonsils to be 3mm-6mm lower than the MRI image predicted. A laminectomy was performed only in cases where the herniation was at or beyond the C1 level, and even then a standard laminectomy was only performed for herniations of more than 15mm.

In turning their attention to the dura, the surgeons used the CDU to evaluate the size of the cisterna magna and the amount of CSF flow. In general, they found small cisterna magnas and very little to no CSF flow. After opening the dura, they would again evaluate the cisterna magna and CSF flow to see if opening the dura alone was sufficient. In most cases it wasn't and they opened the arachnoid as well to remove adhesions and see if the tonsil themselves needed to be reduced in size.

After sewing a patch into the dura, the surgeons evaluated the decompression using the CDU. They measured the space around the cerebellum to ensure it was large enough and they measured the CSF flow. They found that good CSF flow had a peak velocity of between 3 - 5 cm/s, was clearly moving in both directions, and clearly varied with breathing and the heart beat.

While it is interesting to gain insight into how an experienced surgeon tailors his operative technique to individual patients, the surgeons acknowledge that the true value of using CDU will not be known until it can be shown to improve patient outcomes. Fortunately, Dr. Milhorat is performing a longitudinal study to do just that; correlate CDU guided surgery with pre and postoperative MRI, cine MRI, patient symptoms and long-term outcomes.

Even if and when CDU is objectively shown to improve surgical outcomes, it is not clear how quickly it would be adopted by the neurosurgical community. Dr. Bolognese has spent years mastering the technology and the training hurdle for other surgeons is unknown. In addition, it may be hard to sway surgeons from their own preferences. In comments published in the same journal issue, other neurosurgeons praise Dr. Milhorat's work, but at the same time talk about their own techniques. For example, Dr. Harold Rekate states he prefers to avoid shrinking the cerebellar tonsils, whereas Dr. Ulrich Batzdorf believes the tonsils should be reduced and has been doing just that for a number of years.

Unfortunately for patients, until there is an overwhelming amount of objective, scientifically rigorous studies showing which surgical techniques work better than others, it appears that just as it is for surgeons, patients will have to make their own judgment calls.

Ultrasound

part to replace or repair a defect

laminectomy - surgical removal of part (the bony arch) of one or more vertebrae

suboccipital craniectomy - surgical removal of part of the skull, or cranium, in the back of the head, near the base

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

ultrasound - non-invasive imaging technology which uses high-frequency sound waves to create pictures of internal structures

- Diagnostic imaging technique developed out of Navy SONAR technology
- Uses high-frequency sound-waves
- A device called a transducer transmits the sound waves and records the reflections off the body's structures
- A computer creates an image from the reflected sound waves
- First used medically in the 1960's to evaluate pregnancies
- Now used for a wide variety of purposes
- Doppler Ultrasound is capable of showing fluid flows, such as blood and CSF
- Ultrasound is very safe, non-invasive, and involves no radiation