Key Points

1. 11 pediatric patients were tested at 3 different times during decompression surgery using brainstem auditory evoked potentials (BAEPs).
2. BAEP's monitor activity in the brainstem - often compressed in patients with Chiari.
3. Significant improvement in BAEP's was found after removal of bone, but before opening the dura.
4. No further improvement in BAEP's was found after opening the dura.
5. BAEP results are not directly linked with clinical improvement and more research is needed to determine if bony decompression alone is sufficient for clinical improvement.

Definitions

atlanto-occipital membrane - fibrous membrane connecting the top vertebra with the edge of the foramen magnum

BAEP's - Brainstem Auditory Evoked Potentials; diagnostic tool involving the use of sound to stimulate pathways in the brain and recording the electrical response

brainstem - base of the brain which connects to the spinal cord

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 - 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

Testing During Surgery Help Resolve The Surgical Debate?

One aspect of the debate on the best surgical approach to treating CM/SM revolves around whether all parts of a full decompression are necessary - craniectomy, laminectomy, duraplasty, and for some tonsillar resection. Now, a team out of Columbia led by Dr. Neil Feldstein and Dr. Richard Anderson has published a study suggesting that most of the decompression may occur with just the removal of bone (craniectomy, laminectomy).

Whether to open the dura during surgery is a hot topic because doing so increases the risk of complications during and after surgery. In fact one study which compared surgeries with and without duraplasty showed significantly higher post-surgery complication rates for the patients who received duraplasty even though overall outcomes were the same for both groups. Other surgeons have reported successful surgical outcomes opening the dura but not inserting a patch, and even not opening the dura at all.

What Dr. Feldstein's team did was to monitor patients at various times during surgery using Brainstem Auditory Evoked Potentials (BAEP's) in an attempt to identify the contribution from different parts of the surgery. BAEP's have been in use for decades to diagnose hearing loss in infants and to assess neurological function BAEP's work by stimulating certain paths in the brain using audible clicks of varying loudness and frequency. The response along these pathways - which involve the brain stem - are measured using patch like electrodes placed on the skin and compared against standards developed over many years. BAEP's are relevant to Chiari patients because the malformation causes compression of the brainstem which can affect the response time of signals passing through there.

The Columbia study, published in a paper titled *"Improvement in brainstem auditory evoked potentials after suboccipital decompression in patients with Chiari I malformation"*, in the Journal of Neurosurgery, March 2003, looked at 11 eleven pediatric Chiari patients, both with and without syringomyelia. All patients underwent a similar decompression procedure involving a craniectomy, laminectomy, and duraplasty. BAEP's were measured at three times during the procedure: when the patients were laying flat prior to surgery to establish a baseline, immediately after opening the bone and releasing the atlanto-occipital membrane but prior to opening the dura, and after opening the dura.

The researchers found that the average baseline BAEP was 4.19 msec. At the second measurement - after opening the bone - the time had improved to 4.03 msec, but there was no change at the third measurment - after opening the dura. These results are statistically highly significant and not likely due to chance.

So what does this mean? Since the study was preliminary in nature, it does have limitations, which the researchers freely admit and discuss. The biggest limitation is that there is no direct evidence that improved BAEP times equate to improved clinical results. Since all patients underwent a duraplasty, more research is needed to determine if just removing bone is sufficient to achieve good clinical results and demonstrate that BAEP responses can predict clinical outcome. Logically however, one would think that since Chairi involves compression of the brainstem, that improved brainstem response would be related to improvement of symptoms related to brainstem compression. But this line of thinking leads to a second limitation of the study involving syringomyelia. The connection between improved BAEP's and syrinx reduction is less clear and it may be that a bony decompression alone can resolve Chiari symptoms, but a duraplasty is needed to enable a syrinx to collapse.

The researchers also point out that long-term failure after Chiari surgery is a well known event and their limited follow-up period - 12 months - is not sufficient to make any statements about long-term results. Along a different line, it is not clear the results would extend to adult patients. It may be that the dura is more flexible in children and it thickens and hardens in adults. If this were true, it would mean that the dura itself could contribute to compression in adults but not children.

Given the study limitations, the team is cautious about interpreting their results. While the study clearly demonstrates that improvement in BAEP's occurs only after bone removal, the surgeons clearly state they are not advocating bony decompression alone as a surgical technique. Although Dr. Feldstein did not return a request for comment, he goes so far as to state in the paper that he believes that "opening of the dura accompanied by duraplasty are essential parts of the operative procedure." The researchers go on to say they hope that BAEP's become useful tools during surgery to help guide a surgeon in determining how much bone to remove and whether to perform a duraplasty.

No matter how you interpret the results, a rigorous, scientific focus on identifying the best surgical technique combined with the development of intraoperative testing is clearly a sign of good things to come.

The Clinical View of Surgery

Ed. Note: The following is excerpted from the operative note in my medical records; the surgery was performed

cisterna magna - CSF filled space below the cerebellum

craniotome - surgical instrument for cutting the bone of the skull

decompression surgery - common term for any of several variations of a surgical procedure to alleviate a Chiari malformation

dura - thick outer layer covering the brain and spinal cord

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

foramen magnum - opening at the base of the skull, through which the spinal cord passes

hemostasis - prevention of bleeding

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

msec - millisecond, one thousandth of a second

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

vertebra - segment of the spinal column

on 1/21/99.

The patient was taken to the operating room where intravenous and inta-arterial lines were placed. General anesthesia was induced and the patient endotracheally intubated. Once the tube was secured, the Mayfield skull clamp was applied. The Foley catheter was placed. The patient was rolled into the left lateral decubitus position. The head position was fixed in the Mayfield head holder and the skin prepped and draped in usual fashion.

A linear skin incision was made and carried through the skin and subcutaneous tissue to the paracervical fascia. The paracervical fascia was incised with a cutting cautery. A midline subperiosteal dissection was performed. Self-retaining retractors were placed. The occiput was identified. Adhesions at the base of the foramen magnum were freed up. Craniotome was used to turn a small craniotomy flap in the suboccipital region. Measured that the patient would need 3.5cm to decompress. This was the distance that was taken.

The dura was opened. The CSF was under a good bit of pressure as were the cerebellar tonsils. The cisterna magna was drained. A dural graft was cut to length and sewed into place. Things were really quite nicely decompressed.

Meticulous hemostasis was achieved with bipolar cautery. Bone edges were waxed. The wound was thoroughly irrigated. Thrombin-soaked Gelfilm was placed over the dural defect. 2-0 Vicryl was used to close the paracervical musculature and paracervical fascia. The same was used for the subcutaneous tissue. Staples were placed on the skin. Evoked potentials were stable throughout.