Chiari Academy Video Transcription
Beyond Tonsillar Position – Dynamic Measures of Chiari

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[Music]

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In the previous module we looked at several static morphometric measures

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which are often different in Chiari patients,

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but on their own still don't tell the whole Chiari story

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In this module, we will try to fill in more pieces of the puzzle by examining the dynamic

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measures of CSF flow, longitudinal impedance, and neural tissue motion.

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Cerebrospinal fluid, or CSF, is a water like liquid which bathes the brain and

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spine and serves a number of vital functions such as providing protection from injury,

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delivering nutrients, and removing waste products. CSF is continuously created and absorbed, and it

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circulates throughout the brain and spine in the subarachnoid space which sits below the dura.

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CSF circulation is driven primarily by the cardiac cycle and is influenced by breathing.

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When the heart contracts, blood is pumped into the brain which in turn forces CSF out of the

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brain and into the spine. During the second part of the cardiac cycle, this process is reversed and
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CSF flows back into the brain from the spine. The end result is that CSF essentially sloshes
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back and forth between the brain and spine in a pulsatile fashion. How hard a person is breathing
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influences this movement by changing the relative pressure between the brain and spine areas.
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With Chiari, herniated tonsils obstruct the CSF pathways between the brain and
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spine and restrict, or resist, the natural flow back and forth. In fact,
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one of the main goals of decompression surgery is to restore the natural flow of
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CSF across the craniovertebral junction by opening up the blocked passages.
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Over the years, researchers and clinicians have focused their attention on trying to
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understand what is happening dynamically at the craniovertebral junction by quantifying
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the amount and nature of the CSF flow, the resistance introduced by the herniated tonsils,
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and the movement of the cerebellum and brainstem in response to the cardiac cycle.
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MRIs are amazing machines, and they can be programmed to do more than take static images.
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Specifically, they can be used to capture the flow of CSF using one of several
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different techniques. The results can then be evaluated qualitatively, meaning just visually,

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or through quantitative analysis to determine specific velocities and other characteristics.

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Despite some early promise, the clinical usefulness of qualitatively assessing CSF

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flow studies is not clear. Not all surgeons use them, but they may add value in some cases in

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trying to decide if decompression surgery will help relieve the patient's symptoms.

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Quantitative studies comparing Chiari patients to healthy volunteers have found that Chiari

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patients have disrupted flow patterns and higher velocities around the herniated tonsils

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which return to closer to normal after surgery. Unfortunately, this disrupted pattern is also

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seen in subjects with tonsillar herniation but no symptoms. However, research has shown that people

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with herniations but enough space that the flow is not disrupted tend to NOT respond to surgery. The

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limited utility of CSF flow has led researchers to look for additional dynamic measures.

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In the field of fluid dynamics, resistance to the pulsatile motion of a fluid – like CSF into

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and out of the brain – is called longitudinal impedance and Conquer Chiari researchers have

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conducted several interesting studies on this topic. Specifically, using high resolution MRI

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imaging they developed a technique to calculate longitudinal impedance based on an individual's

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unique anatomy. Using this technique, they found that the average longitudinal impedance among

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adult Chiari patients was 551, which was more than double the average impedance of healthy volunteers
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at 220. In a separate study they also found there was a significant difference in the impedance
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between Chiari patients with and without cough headaches. Specifically, the average impedance of
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patients with cough headaches was 776, compared to an average of only 285 for patients without
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cough headaches. However, these are just averages and not every patient with a cough headache had
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a high impedance, just as not every patient without cough headaches had a low impedance.
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Unfortunately calculating longitudinal impedance for a specific individual is a labor and computer
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intensive process and is currently not practical for use in a diagnostic capacity. However,
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this work does provide important clues as to what is happening dynamically in Chiari patients.
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Next, we will turn our attention from CSF flow and impedance to the motion of brain tissue,
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specifically the cerebellum and brainstem. During decompression surgery, surgeons have noted that
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the cerebellar tonsils of Chiari patients visibly pulsate with the heartbeat. In fact,
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one indication of adequate decompression is that this pulsation is reduced. Conquer
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Chiari researchers have taken this further by quantifying this movement using an extremely
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accurate MRI technique called displaced encoding with stimulated echoes, or DENSE. DENSE imaging

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has been shown to accurately capture tissue motion down to the width of a human hair or

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less. In DENSE studies, researchers have shown that the cerebellums of Chiari patients move on

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average 100% more than healthy volunteers and that their brainstems move 64% more. This extra motion

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translates to a 50% increase in the strain placed on the cerebellum of Chiari patients.

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In a second study of patients who underwent DENSE imaging both before and after surgery, researchers

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found that surgery reduced the motion of the cerebellum by nearly half and the brainstem by

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22%. Finally, a recent study found that surgical patients with more tissue motion before surgery

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experience the largest reductions in motion after surgery. However,

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linking DENSE measured motion with specific Chiari symptoms has proven to be elusive. So,

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while it is clear that Chiari patients have more tissue motion and resultant strain than

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healthy people, in absolute terms this motion is very small and the impact is not clear.

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On the other hand, the data so far has been collected while lying in an MRI machine and

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the increase in strain that Chiari patients may experience during coughing, straining,

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or exercising is not known and might be enough to damage neural connections.

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To summarize, Chiari patients in general exhibit disrupted CSF flow around the cerebellar tonsils,
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higher levels of impedance to the CSF flow, and an increase in motion of the
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cerebellum and brainstem, all of which can be quantified. However, much like with the static,
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morphometric measurements, this is not true for all Chiari patients and other
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than the cough headache these dynamic markers are not strongly linked with specific symptoms
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or overall symptom severity. So while they add more pieces to the puzzle, it is still
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not clear why some people with herniations don't experience symptoms or why the majority of Chiari
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patients aren't diagnosed until their early thirties. In the next module we will discuss
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a new theory which Conquer Chiari researchers have developed that addresses these questions.