Key Points

1. Sleep apnea is very common among Chiari patients, with 50%-75% suffering from some type
2. In adults, apnea has been linked to cognitive impairments; in children can lead learning problems and poor school performance
3. Study looked at whether apnea causes measurable changes in the brains of children
4. Compared 19 children with moderate to severe apnea to 12 healthy controls
5. Children with apnea scored significantly lower on IQ tests, and tests of verbal fluency and working memory
6. Advanced imaging showed chemical changes in the frontal cortex and hippocampus brain regions of the apnea children
7. It is not known if these changes result in permanent deficits

Definitions

body mass index (BMI) - a general measure of obesity, derived from height and weight

executive functions - a set of higher order cognitive functions, such as goal-setting, prioritizing, organizing, and problem solving

frontal cortex - front part of the brain believed to be involved in higher order functions such as planning and reasoning

hippocampus - a part of the brain involved in learning and memory

IQ - a measure of overall intelligence, a score of 100 represents average (median) intelligence

metabolism - all the processes by which the body breaks down food and releases and regulates energy

metabolite - a substance created during metabolism

Sleep Apnea Causes Brain Changes In Children

September 20, 2006 -- Sleep apnea is a fairly common disorder which involves repeated interruptions in breathing, resulting in minor arousals, during the night. In obstructive sleep apnea, the most common, there is a physical obstruction to the airway which interferes with breathing. Sufferers snore loudly and wake up gasping for breath. The repeated arousals during the night result in excessive sleepiness during the day, which in turn can lead to an increase in accidents.

With up to 30 million Americans estimated to be struggling with sleep apnea, major research publications in this space can garner a lot of attention. That was the case recently when a group of scientists from Johns Hopkins (Halbower et al.) announced that not only can obstructive sleep apnea affect childrens' learning and memory, but that left untreated, may result in fundamental changes to the brain.

While this was widely reported in the mainstream media, the implications of this finding for the Chiari community are even more significant. As has been reported previously by this publication, research has shown that a high percentage of Chiari patients suffer from sleep apnea. In fact studies involving formal sleep testing indicate that as many as 50%-75% of Chiari patients may fit into this category.

The percentage is so high, scientists believe, because in many Chiari patients the muscles of the throat and larynx are weak, and during sleep can actually block the airway. Another possibility is that the herniated cerebellar tonsils place pressure on the sleep center located in the brainstem. No matter the underlying mechanism, and even though it is a secondary condition, it is important for Chiari patients (or parents) to understand the significant impact which continued sleep apnea can have.

A growing body of evidence is beginning to show that sleep apnea can result in cognitive impairments in adults (plus an increased risk of car accidents) and memory, learning, and school performance issues in children. In order to study the effects of apnea on children in more detail, and to determine if the repeated interruptions in oxygen result in physical changes in the brain, the Johns Hopkins team used polysomnography (sleep testing), neuropsychological testing, and advanced imaging to compare a group of children with moderate to severe obstructive apnea to a group of healthy children. Their results were recently posted on the website of PLoS Medicine, a free, open-access journal.

For their study, the researchers recruited 19 children, ages 6-16, with confirmed obstructive sleep apnea. They then recruited a control group of 12 healthy children such that the groups were similar in age, gender, ethnicity, and socio-economic status. Children with IQ's below 75, with neurological problems, or who did not speak English were excluded. All the children, from both groups, underwent formal sleep testing, neuropsychological evaluations, and MRI spectroscopy.

The neuropsychological tests were designed to measure overall IQ, executive functioning, memory, motor speed, and visual-spatial perception. MRI spectroscopy is an advanced imaging technique based on MRI technology which can measure the levels of specific substances, known as metabolites, in the brain. Metabolites are the by-products of the brain's normal metabolism and functioning, and abnormal levels are indicative of disease or neuron damage.

The results of the sleep testing were as expected given the design of the study (see Table 1). Namely, that all the children in the apnea group suffered from moderate to severe apnea, whereas none of the healthy children did. However, it was also noted that the average Body Mass Index (BMI) of the apnea group was significantly larger than the control group. BMI is derived from a person's height and weight and is a simple measure of obesity.

The neuropsychological testing revealed that there were significant differences between the two groups in overall IQ, verbal fluency, and working memory. Specifically, the average IQ of the apnea group was a full 15 points below their healthy counterparts. Interestingly, some of the cognitive differences which are found in adults with apnea were not found in this group of children.

The results from the imaging were even more startling, with the apnea children showing abnormal levels of certain metabolites in the frontal cortex and the hippocampus. The frontal cortex, located in the front of the brain, is believed to control high order functions such as planning and reasoning. The hippocampus, located deeper in the brain, is thought to play a critical role in learning and memory. Interestingly, the researchers thought they might find a difference in the cerebellum as well, but they did not.

While the implications of this are striking, namely that apnea may cause structural changes in the brain, it is important to keep in mind that the children in this study all suffered from fairly severe apnea and tended to have

neuron - a nerve cell

neuropsychological testing - evaluation of a person's cognitive and motor abilities through structured tests

obstructive sleep apnea - a disorder characterized by repeated disruptions (and arousals) in breathing during sleep

polysomnography - sleep testing conducted in a laboratory

proton MRSI - type of imaging, based on MRI, which can show the amount of certain metabolites present in the brain

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

Source

Halbower AC, Degaonkar M, Barker PB, Earley CJ, Marcus CL, Smith PL, Prahme MC, Mahone EM. Childhood Obstructive Sleep Apnea Associates with Neuropsychological Deficits and Neuronal Brain Injury.
PLoS Med. 2006 Aug 22;3(8) [Epub ahead of print]

high BMI's, which is another health risk factor. Similarly, although the abnormal metabolite findings are similar to what is seen in diseases that affect the brain, the true impact of these chemical changes is not fully understood. Finally, it can not be determined from this study whether the changes seen in the brain are reversible with treatment for the apnea.

However, given the critical nature that these brain structures play, especially during development as a child, it is important to be aware of, and understand, the potential implications of untreated sleep apnea. And with apnea so common in the Chiari community, we should all be thinking about whether that fatigue during the day may in fact be due to problems breathing at night.

Table 1
Sleep Testing Results, Apnea vs Controls (Average Scores)

	Apnea (19)	Control (12)
BMI	27.9	19.7
Apnea Index	34.6	0.2
Arousal Index	15.7	5.0

Table 2
Significant Differences In Neuropsych Testing Between Apnea and Control Groups

	Apnea (19)	Control (12)
IQ	85.8	101.1
Verbal Fluency	9.7	12.0
Working Memory	8.3	15.5

Note: *The above differences were statistically significant, meaning the difference is unlikely to be due to chance*

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