It's all in your head: NASA investigates techniques for measuring intracranial pressure

December 18 2013

Expedition 36/37 Flight Engineer Karen Nyberg of NASA uses a fundoscope to take still and video images of her eye while in orbit. This was the first use of the hardware and new vision testing software. Credit: NASA

Do you ever turn your world upside down by standing on your head? After a few minutes you might feel some pressure in your face and around your skull. This is because headstands invert the body's blood flow, pushing more blood toward your head.

Astronauts in microgravity experience something similar. Without gravity pulling body fluids down toward their legs and feet, the fluids move toward the upper body. Scientists believe this causes fluid congestion in the head and increased pressure in the brain, known as intracranial pressure, which may be causing vision impairment in some crew members. The pressure and associated vision changes can cause what is known as "Visual Impairment/Intracranial Pressure" (VIIP syndrome), and it is one of NASA's top human spaceflight risks.

Researchers funded through NASA's Human Research Program are working to monitor, understand and prevent VIIP by investigating several non-invasive methods for measuring intracranial pressure through the ear, eye and head—techniques that are on the cutting edge of advanced space- and Earth-based medicine. Their work could have significant implications for both our astronauts in space and people on Earth, turning the way increased intracranial pressure is measured on its head.

"Determining the dynamics of intracranial pressure in microgravity is key to understanding the root cause of the VIIP syndrome and developing effective countermeasures," says. Dr. Christian Otto, lead scientist of NASA's VIIP Risk Project.

Right now the only way to measure intracranial pressure definitively is through invasive techniques like a lumbar puncture—also known as a spinal tap. Lumbar punctures are considered the gold standard for measuring intracranial pressure because the test provides direct measurements of the fluid that surrounds the spinal cord and the brain. However; the procedure is complicated to perform in orbit. It carries risks on Earth as well.

Non-invasive methods could provide clinicians and researchers with accurate and safer ways to determine if intracranial pressure is directly correlated to vision impairment. If so, the tests may help identify what other factors, like cardiovascular health or issues with the central nervous system, may predispose some astronauts to increases in brain pressure.

Fortunately, the brain's interface with various bodily structures such as blood vessels, ears and eyes provide scientists with ways to indirectly measure intracranial pressure non-invasively. Scientists now are attempting to correlate changes in these parts of the head to intracranial pressure.

Expedition 37/38 Flight Engineer Michael Hopkins of NASA performs ultrasound eye imaging in the Columbus laboratory of the International Space Station. European Space Agency astronaut Luca Parmitano assists. Credit: NASA

The Ear

One technique, tympanic membrane displacement, measures pressure that is transferred from the brain to the ear via a small channel that connects the two. Movement detected in the eardrum provides researchers with an indication of intracranial pressure levels. A second technique emits sounds into the ear at two frequencies. Because pressure in the head affects how the inner parts of the ear vibrate in response to these sound waves, scientists can measure the movements to determine if the pressure in the head has increased. This is called distortion product otoacoustic emissions.

The Eye

The eye also is a valuable yet possibly confounding source of information. According to Jennifer Fogarty, Ph.D., a NASA clinical translational scientist, the rigid structure of the skull makes the eye vulnerable to increased pressure because it is a pliable organ. This means measuring changes in the eye allows scientists to assess changes in intracranial pressure. Researchers can leverage easy access to the eye as the gateway into the brain to study intracranial pressure.

The eye may also be affected by spaceflight independent of changes in intracranial pressure. So, it is important to be able to determine what is happening to the eye due to changes in blood flow to and from the eye itself and what is happening to the eye due to increases in intracranial pressure.

Several ocular methods allow scientists to look directly into the eye structure to estimate intracranial pressure. These provide measures of central retinal vein pressure (venous ophthalmodynamometry with fundoscopy), pupil diameter (pupillometry) and optic nerve sheath diameter. The optic nerve sheath insulates and protects the optic nerve. It is connected to the space around the brain and expands when pressure rises.

Scientists also are measuring blood flow in the vessels feeding and draining the eye to determine intracranial pressure. One technique uses ultrasound over the closed eyelid to compare two sets of arterial pulses—both inside and outside of the brain—in response to external pressure placed on the eye. This technique is called two-depth transcranial Doppler .

The Head

Other techniques measure changes within the head in non-invasive ways. They include Doppler images of the brain's blood vessels; magnetic resonance imaging; near-infrared spectroscopy, which measures brain activity through blood movement; and pulse phase-lock loop, which measures skull movement associated with pulses in intracranial pressure.

Expedition 34/35 Flight Engineer Tom Marshburn of NASA performs a tonometry eye exam on Chris Hadfield of the Canadian Space Agency in the Columbus module of the International Space Station. Tonometry measures intraocular eye pressure. Credit: NASA

NASA researchers already are using some of these methods, like fundoscopy, to take measurements before, during and after missions aboard the International Space Station. They use the data to determine how spaceflight relates to changes in the eyes and intracranial pressure. Others, like tympanic membrane displacement, still are being evaluated for flight.

Some subjects participating in these investigations undergo lumbar puncture during Earth-based device testing. This allows researchers to validate the device's accuracy relative to absolute intracranial pressure obtained from the results of the lumbar puncture. The lumbar puncture is performed only if a subject already needs the procedure for medical reasons.

Beyond the device's accuracy, NASA researchers also must consider the size and weight of the devices for spaceflight, as well as the device's ease of use for non-medical personnel. Some techniques can be performed using virtual guidance where Earth-based medical personnel provide training to crew members performing medical procedures in orbit.

This work into non-invasive testing to measure intracranial pressure has both space- and Earth-based applications. For patients suffering from conditions like hydrocephalus and Idiopathic Intracranial Hypertension, an increased pressure around the brain without an apparent cause like tumors or other diseases, these techniques could provide alternative ways to measure intracranial pressure without the risk or discomfort associated with a lumbar puncture.

According to Otto, as these devices are evaluated, researchers continue to characterize the problem— gaining greater insight into the effects of increased intracranial pressure on individuals both in space and on Earth.

This research just may turn the medical world upside down.

Provided by NASA

Citation: It's all in your head: NASA investigates techniques for measuring intracranial pressure (2013, December 18) retrieved 6 July 2024 from https://phys.org/news/2013-12-nasa-techniques-intracranial-pressure.html