National Aeronautics and Space Administration

THE LIFETIME SURVEILLANCE OF ASTRONAUT HEALTH

Newsletter

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Editor's Note: *This spring's newsletter focuses on NASA's rapidly evolving interest in visual acuity changes associated with microgravity environments. There are currently a variety of theories and studies focusing on concerns recently brought to light, which we outline for you here. Lifetime Surveillance of Astronaut Health (LSAH) staff have spent countless hours on these investigations as part of our occupational surveillance program, and will continue to work towards better understanding and mitigating space flight health risks.*

What's New in Space Medicine - Can you say "VIIP"?

By: William Tarver, MD

NASA has documented that several long duration astronauts have experienced in-flight and postflight changes in vision and eye anatomy, including degraded distant and near vision, swelling of the back of the eye (optic disc and retina), and changes in the shape of the globe (flattening of the back of the eye). In a few astronauts we have also documented postflight increases in the pressure of the fluid that surrounds the brain and spinal cord. This is referred to as increased intracranial pressure (ICP). The functional and anatomical changes have varied in severity and duration. In the postflight time period, some individuals return to preflight visual acuity, while others have experienced changes that remain significantly altered compared to preflight. In addition, the increased ICP appears to persist in the postflight time period. Currently, the underlying causes of these changes are unknown but the space flight community at NASA suspects that the shift of blood toward the head and the changes in physiology that accompany it, such as increased intracranial pressure, play a significant role.

In looking for a terrestrial clinical equivalent, the Space Medicine Division (SD) found that Idiopathic Intracranial Hypertension (IIH) has some significant similarities as well as some major differences. IIH tends to occur in 20 to 45 year old obese females, and ICP measurements in IIH cases are much higher than any ICP measures on astronauts. Finally, IIH patients have a high incidence of severe disabling headaches, a finding not seen in our astronauts. So, while IIH is the closest terrestrial clinical model for us to compare against, the NASA documented clinical entity remains a unique spaceflight associated problem.

To address this unique problem, the Space Life Sciences Directorate (SLSD) at NASA Johnson Space Center has assembled a Visual Impairment Intracranial Pressure (VIIP) project team to address both operational capabilities and the development of a research plan. The operations arm of the project is addressing the implementation of medical requirements, and the immediate clinical needs of the NASA flight surgeons, such as enhanced diagnostic and treatment capabilities to respond to in-flight and postflight diagnosis and treatment. The research arm is developing a multidisciplinary, collaborative research approach that will consist of a steering committee, a scientific advisory panel, and a research collaboration team composed of clinical, translational, and fundamental research experts. This integrated approach is designed to effectively and efficiently address immediate clinical and operational needs while developing an interdisciplinary and collaborative research project.

NASA has determined that the first case of increased intracranial pressure with visual changes was observed in an astronaut after a long duration mission aboard the International Space Station (ISS). The astronaut reported vision changes after 3 months into a 6-month mission on ISS, necessitating use of his reading glasses when gazing at the earth. This individual experienced a degradation in distant vision during the flight, and postflight eye exams revealed changes in

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the back of the eye that included swelling and tissue remodeling. Additional postflight testing was pursued to characterize the pathology. Findings suggested a persistent mild intracranial hypertension. Additional cases of altered vision have been reported since this first case and one case has included the report of a visual field defect which resulted in the astronaut having to tilt the head approximately 15 degrees to view instruments and procedures. This visual field defect persisted for over twelve months after flight. This type of functional deficit is not only of concern for the individual but is of concern to the mission and ISS program.

A change in vision during space flight is not a new finding; vision changes have been documented through medical testing, research, and anecdotal reports over the last 40 years. Changes in vision reported by astronauts in the past were often minor, transient, and not accompanied by other symptoms or significant clinical findings. Older astronauts over the age of 40 appear to be predisposed to these visual difficulties during prolonged exposure to space flight. Due to the recently reported and documented significant functional deficits in visual acuity, the persistence of the symptoms after the mission, and the detailed anatomical images suggesting tissue changes, NASA is taking a much more aggressive approach to addressing these changes through the VIIP project.

The Space Medicine Division (SD), in collaboration with the SLSD VIIP project, has implemented an expanded set of medically required pre-, in-, and postflight testing to determine the presence and degree of the changes in vision and the anatomy of the eye (see accompanying article on page 5). In order to facilitate the in-flight collection of data, SD and VIIP have increased the on-orbit imaging capability by flying new devices (a video fundoscope and a tonometer) and developing new processes to use the existing on-orbit ultrasound. SD and VIIP are also planning to evaluate a non-invasive device to measure ICP in-flight and postflight. This increased capability and expanded set of tests will be used to inform the medical treatment of the individual astronauts as well as more comprehensively characterize changes in vision and eye anatomy. The results of these tests and images can function on an individual level to inform personal medical care and on a population level to inform occupational health (risk management) decisions. Additionally, all of these data are used in conjunction with human research data acquired over the life of the space program to determine the potential scope of the forward research plan being developed by the VIIP project.

The VIIP project is working in concert with the NASA Human Research Program (HRP) on the development of an integrated and collaborative research model. To date, SLSD has held three summits with outside scientific and clinical advisors. The first was an exhaustive review of the ophthalmic findings, held in 2009. A second summit was held in early 2011 and expanded to cover the whole entity we refer to as VIIP. Finally, we just hosted the VIIP rCAP (research Clinical Advisory Panel) in December 2011. Combined, these advisory groups have generated significant input into clinical care decisions, operational medical requirements, and research direction. They have been instrumental in providing expert guidance on this space medicine unique clinical entity, and will inform much of our work moving forward.

For Your Information

If you want a copy of your exam results, please complete and sign a release form while you are visiting the Clinic for your examination. The form is called *Privacy Act Disclosure Authorization and Accounting Record (DAAR)*, or NASA form 1536.

...and Ours

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Vision Changes Observed After Space Flight

By: Sara Perry, MA, MPH

For the astronaut in space, the ability to see clearly is paramount to function and survival. As a result, NASA runs a large number of pre-, in-, and postflight tests to evaluate visual ability and to document changes that may have occurred during the mission. More detailed information on these tests can be found in the article by Bini Kadwa on page 5.

In the October 2011 issue of Ophthalmology, Dr. Thomas Mader and co-investigators published a scientific article, “Optic disc edema, globe flattening, choroidal folds, and hyperopic shifts observed in astronauts after long-duration space flight”. This article documents eye anomalies and vision loss in both short- and long-duration mission astronauts that are thought to be caused by exposure to microgravity conditions.

Study Population & Data Collection

This study is a combination of a case series report and a cross-sectional study. It discusses ophthalmic findings in 7 astronauts after long-duration missions and also presents the results of subjective vision changes in 300 postflight vision questionnaires. All 7 cases occurred in male astronauts, with an average age of 50.2, and all had completed approximately 6 months of continuous orbital flight. Some of the participants in both study groups were repeat flyers.

Analyses

Since 1989, astronauts have completed a postflight survey questionnaire that asks about subjective vision changes during short- and long-duration missions. The eye examination testing protocol at NASA has expanded over the years, partially as a result of reported vision changes by questionnaire participants. As a result, the testing done on the 7 case series astronauts varies. However, all underwent the complete eye examination protocol available at the time of their exams.

Results

The results of the postflight questionnaires indicated that 38 (6%) short-duration astronauts and 5 (11%) long-duration astronauts experienced a mild, moderate, or severe subjective change in distance visual acuity. One hundred and thirty six (23%) short-duration astronauts and 19 (47%) long-duration astronauts experienced a mild, moderate, or severe subjective change in near visual acuity. One short-duration astronaut and 3 long-duration astronauts experienced severely decreased near visual acuity. Zero short-duration astronauts and 2 long-duration astronauts experienced severely decreased distance visual acuity. It is noteworthy to report that some of these vision changes persisted several years after flight.

For the case series report, detailed analyses of pre- and postflight eye examinations are described. Six of the 7 cases reported a change in vision either in-flight, postflight, or both. The change was a decrease in near vision ability that improved in the days postflight in some astronauts. In some of these cases uncorrected near visual acuity has not improved several years postflight. In 5 cases, there was a significant shift in vision and a flattening of the globe of the eye. All five were found to have swelling of the optic disc and the area around the optic nerve and a thickening of the nerve fiber layer. Four of the 7 showed folds in the back of the interior surface of the eye (i.e., choroidal folds), with one astronaut still showing presence of these folds in one eye more than 5 years postflight. Three astronauts also had identifiable “cotton wool spots,” which indicates damage to the nerve fibers.

Conclusions

The exact cause of these findings is still being debated, but the most accepted hypothesis is that intracranial hypertension likely caused by microgravity headward fluid shifts may cause a rise in optic nerve sheath pressure. Another hypothesis suggests that these fluid shifts near the optic nerve may cause swelling in this location, resulting in tissue and structural changes to the eye. It could also be due to swelling of the vascular layer of the eye (i.e., choroid).

While the exact etiology of these conditions has not yet been resolved, more cases are being identified and studied to learn more about the cause of these eye abnormalities. NASA has identified that there is a

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problem, which warrants more testing in astronauts. The article has stimulated research into potential ocular therapies to prevent future ocular and visual acuity decreases in all astronauts.

Reference

Mader TH, Gibson CR, Pass AF, et al. Optic disc edema, globe flattening, choroidal folds, and hyperopic shifts observed in astronauts after long-duration space flight. Ophthalmology. 2011;118:2058-69.

Please note: additional cases have been identified since the publication of this article.

A copy of this article can be purchased through the publisher at:

http://www.ophsource.org/periodicals/ophtha/article/S0161-6420%2811%2900564-1/abstract

Ground and In-Flight Testing for Visual Impairment and Intracranial Pressure

By: Bini Kadwa

In February 2011 Space Life Sciences held a Visual Impairment Intracranial Pressure (VIIP) Summit at JSC to solicit input and recommendations from a varied group of experts from the fields of medicine and research.[1]

The panel concluded that NASA is doing an adequate job of monitoring and documenting changes in vision and the anatomy of the eye, but provided recommendations in the area of clinical management and fundamental research to determine whether exposure to microgravity is causing increased intracranial pressure (ICP). In accordance with the recommendations, NASA is now conducting tests such as MRI and Optical Coherence Tomography before and after flight in all long-duration astronauts with the goal of establishing the role of ICP in changes in vision and eye anatomy. These tests are in addition to the standard vision testing. By doing so, NASA will one day be able to improve treatment and clinical outcomes due to microgravity environments through prevention and intervention.

Non-Invasive Tests Explained

The following tests are methods used to study the relationship between VIIP, intracranial pressure, and intraocular pressure. This is not a comprehensive list, but it provides information about some important methods NASA is using to effectively diagnose and treat anatomical and physiological changes in the eyes of long-duration crewmembers.

3.0 Tesla MRI - A Tesla is a unit of measurement quantifying the strength of the magnetic field. 1.5 Tesla is the standard for high-field MRI devices, so the 3.0 Tesla is significantly stronger and faster than a 1.5 Tesla scanner. Although use of this modality to study intracranial hypertension is relatively new, it is becoming widely accepted as the 3.0 Tesla MRI gives a "much greater fidelity and enhancement of the optic nerve, optic disc, and the interface of the sheath to the retina".[2] This test is used during pre- and postflight testing.

Optical Biometry - Optical biometry uses an infrared laser light to measure axial length, anterior chamber depth, and lens, corneal, and retinal thickness. This method is used during pre- and postflight testing to measure the axial length of the eye.

2D Ultrasound - 2D ultrasound emits sound waves that are reflected and displayed as bright spots on a black background. This mode has the ability to image internal structures of the eye. Because 2D ultrasound devices continue to become smaller and more powerful, this test is performed in-flight with assistance and ground based remote guidance in addition to pre- and postflight ground testing. Thus, correlation between ultrasound imaging and MRI can be accomplished and

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changes in the eye during microgravity can be closely monitored.

Optical Coherence Tomography (OCT) - This is an imaging modality that measures the echo time delay and intensity of back reflected light from internal structures in tissues of the eye. It allows for high resolution images and cross-sectional analysis of the optic disc and retina. With an accuracy of up to 5 microns, OCT is the most precise quantitative tool used to measure internal structures of the eye and capture front portions of the optic nerve. OCT is currently used in pre- and postflight testing with the possible inclusion for in-flight testing in the future. OCT is extremely important in the study of VIIP because NASA studies have shown that it can detect minute nerve fiber layer edema thickening not observable by any other means.

Dilated Fundoscopy - During this procedure the eye is dilated with eye drops and observed with a fundoscope. Fundoscopy gives the examiner a view of the base of the optic nerve and retina which can become swollen and undergo structural changes in the presence of increased pressure.[3] This test is performed pre-, in-, and postflight (in-flight performed with assistance from a crewmember, usually before sleep so the dilated pupil does not interfere with operations).

Tonometry - This procedure is used to measure intraocular pressure. It is generally done by first anesthetizing the surface of the eye, then lightly touching the tonometer to the surface, indenting the cornea. The resistance to indentation is measured by calibrating the pressure sensing tonometer device. This test is important because elevated levels of intraocular pressure may damage the optic nerve and result in glaucoma, while low intraocular pressure, especially if combined with elevated intracranial pressure, can result in optic nerve swelling (i.e., papilledema).[4] Tonometry is currently performed pre-, in-, and postflight.

What if Abnormalities are Seen?

If evidence of vision change, papilledema, choroidal folds, or globe flattening is observed from preflight results, treatment may be given with the goal of preserving optic nerve function while managing the increased ICP. Depending on the severity, medical management includes a reduction of dietary sodium intake, stopping any medication or product that might contribute to ICP, and use of medication to decrease the amount of cerebrospinal fluid manufactured. The mainstay medication is a diuretic (acetazolamide) but corticosteroids may be used in conjunction with diuretics. To date, acetazolamide has been used to treat 2 NASA astronauts. In extreme cases involving deterioration of visual function, surgical intervention can be considered. So far, this has not been a consideration.

References

1. Fogarty J, Otto C, Kerstman E, et al. The Visual Impairment Intracranial Pressure Summit Report, NASA/TP-2011-216160, October 2011. (http://ston.jsc.nasa.gov/collections/TRS/_techrep/TP-2011-216160.pdf).

2. “Clinical Practice Guideline for Spaceflight-Induced Intracranial Hypertension”, NASA Internal Document, October 3, 2011.

3. "Fundoscopy - Fundoscopy Eye Exam, Reasons, Procedure to Conduct and Eye Care Post Fundoscopy." Medical Health Tests - Types of Medical Tests, Medical Test Procedures, and Importance of Medical Tests. Web. Accessed 02 Dec. 2011.

4. "Tonometry Testing, Intraocular Pressure (IOP) and Glaucoma Risk on MedicineNet.com." Web. Accessed 02 Dec. 2011. (http://www.medicinenet.com/tonometry/article.htm)

Your One-Stop-Shop for Medical Records

By: Stephanie David, CCS

We've all been there. You've just signed in at a new doctor's office and are promptly given several pages of medical history forms to complete. Your mind goes blank. Are you able to accurately document your past major illnesses and surgeries with correct dates? Can you remember which surgery was done on which knee? What if you received an implant or device during a surgery? Do you know what was used? Do you think you would be able to give them an accurate account of your family's diseases, their start dates, and who has been affected?

Arguably, the single most important information a patient can bring in to a new physician is their medical history, including new information that has occurred since the last visit. If your doctor has a snapshot of your personal and family medical history, they can use this to devise an accurate, appropriate treatment plan.

My role in the NASA/JSC Clinic Medical Records Department is to help maintain accurate, complete medical records for our JSC Clinic patients. When this information is received prior to your annual exam, our JSC Clinic doctors have a more complete medical history that enables them to most effectively target the exam to your personal medical situation, including any acute or chronic medical conditions. When the Lifetime Surveillance of Astronaut Health (LSAH) program and JSC Clinic send an invitation for annual physicals, enclosed is a request for 'Authorization for Disclosure of Protected Health Information'. Timely return of this authorization ensures your records will be received by the time you arrive for your annual exam. Once I receive this release, I obtain all the records, incorporate them into your medical chart, and forward this information to the clinic physician seeing you.

Integrating your external medical records with NASA medical records helps assure the highest quality care here at the Clinic. It also helps the LSAH program provide Space Medicine with a better understanding of astronauts' health and occupational exposures both individually and as a population. But we can also be your 'one-stop-shop' for retrieval and release of all of your medical records. We can provide the following services to you with a written authorization:

1. Release of your JSC Clinic exam results to your personal physician and/or other medical specialists. (Please allow 30 days for all tests to be finalized, electronic documents signed, and a debrief letter generated and sent).

2. Retrieval of your medical records from other providers. Frequently when patients request copies of their medical records for personal use, medical providers charge you for copies of their records. As a professional courtesy, most physicians or hospitals will not charge the JSC Clinic for these same copies. When we request your records, we will retrieve them at no charge to you and dispense with them as you request, such as release to another provider.

3. Release of your past medical documents, whether generated at NASA or received from outside providers, to you or to anyone that you designate.

I look forward to meeting you during your annual physical; please contact me if I can help you with your personal medical record needs.

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Do you have a suggestion for a newsletter article?

We'd love to hear about it!

Send suggestions, comments, or questions to:

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