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Shedding Light on Spaceflight-Associated Neuro-Ocular Syndrome

Dr. Wilner:
There is a troubling ailment that's causing unexplained changes in the brain and eyes. It affects both men and women but only if they belong to a very particular profession, and that profession is human spaceflight.

Welcome to Clinician's Roundtable on ReachMD. I am Dr. Andrew Wilner, and to shed some light on Spaceflight Associated Neuro-ocular Syndrome, we have 2 special guests joining us from NASA, Dr. William Tarver and CAPT Tyson Brunstetter. It's great to have both of you with us today.

CAPT Brunstetter:
Thank you for having us.

Dr. Tarver:
Thank you. Thank you very much.

Dr. Wilner:
So, before we get started, can you explain your roles at NASA? Dr. Tarver, why don't you start us off?

Dr. Tarver:
Well, thank you for having us this morning. Dr. Bill Tarver here. I'm an aerospace medicine specialist. I'm a flight surgeon at NASA. My prime task is to take care of astronauts. I currently have a crew member who's on the Space Station right now, so that's my primary job. My other job is to lead a wonderful clinical team that's evaluating this condition you mentioned, Spaceflight Associated Neuro-ocular Syndrome, which we simplified to SANS, S-A-N-S. We also lead an international consortium, really, because we have partners in Japan, Canada, Europe and Russia, so we have an international partnership that's looking at this condition known as SANS.

Dr. Wilner:
Excellent. And, CAPT Brunstetter?

CAPT Brunstetter:
Yes, thank you again for the invitation to be here today, very happy to be talking. I'm Tyson Brunstetter. I'm a US Navy aerospace optometrist who is detailed to NASA's Johnson Space Center here, and my primary role is to support Dr. Tarver as his deputy. So in that role I support the day-to-day activities of the SANS team, both locally, nationally and internationally, but I also serve as a subject matter expert during ocular data collections from the International Space Station, and I also support the testing and certification of SANS-related medical devices that we actually deploy to the ISS. And then, finally—I think this is one of the more interesting areas among many—is I'm also involved in developing ultra small footprint ocular test devices that we hope will be useful during future expeditionary missions, for example to Mars.

Dr. Wilner:
Cool. Well, thank you both for breaking that down for us. And just to set the stage for this discussion, I remember reading a journal article back in 2012 about how 27 astronauts had ocular changes, including globe flattening and optic nerve protrusion, and a few even had elevated intracranial pressure. I was so fascinated that I included it in my book, Bullets and Brains. So, since then, Dr. Tarver, have these observations turned into something important, or were they just incidental findings?

Dr. Tarver:
Well, we would certainly not qualify them as incidental findings. The thing that kicked this off and was reported in that article you

mentioned is a case of optic disc edema, which is always pathological, and never occurred in an astronaut before, so that was quite eye-opening, no pun intended, for us, and we've continued to have a few more cases since that time. We have not been able to stop them from occurring, and that's because we're still looking into the details of what is causing this very unique condition.

We originally thought we had a version of idiopathic intracranial hypertension, which basically means we're not sure why you have it but you have elevated intracranial pressure. Physiologically, we thought fluids shifted up into the—we know they shift upwards into the head and brain area, and we thought that was probably the main impetus for optic disc edema that occurred, but it doesn't really explain everything. And since then, the details have shown us that we are not dealing with just another version of idiopathic intracranial hypertension. And our long-term risk is decreased visual acuity in individuals who are doing a very, if nothing else, a very expensive test, such as a trip to Mars, and we can't afford to have individuals not performing at the top of their game or when they are in these very challenging mission scenarios. So, not incidental, and we do have occurrences to this day.

Dr. Wilner:
So, with that being said, CAPT Brunstetter, what's being done to learn more about SANS?

CAPT Brunstetter:
So the ocular testing of astronauts has evolved over time, so I'll talk about current day, and I'll talk about it from 2 different perspectives, clinical and research. So, from a clinical perspective, we collect, truly, a tremendous amount of data from astronauts, and we do this preflight, on orbit, and also postflight. So, for example, on the ground, which would be before and after flight, we perform a 3 Tesla MRI of the heads and the orbits, and we also perform a comprehensive eye exam that includes retinal photography, threshold visual fields to measure visual performance and retinal sensitivity, and optical coherence tomography, or OCT. OCT is quickly becoming our go-to device to measure SANS-related changes in the eye, and it's sort of analogous to an MRI, for those who aren't familiar. The OCT provides noninvasive, high-resolution, cross-sectional images of the body, in this case of the retina and the choroid, the vascular bed beneath it and the optic nerve head, a very important tool, the OCT. When the crew members are on orbit, we perform basic vision exams, such as visual acuity and Amsler grid, to look for any visual distortions. We also perform tonometry to measure intraocular pressure when that's indicated, so not all the time. We perform retinal photography, OCT—we actually have an OCT device on orbit—and then also ocular ultrasound. Many additional data points are also collected by NASA's SANS researchers to supplement our clinical data. Results of NASA's Ocular Health Study will be released soon, and it will describe, for example, the time course of SANS development on orbit. And then another research study, NASA's Fluid Shift Study, is currently ongoing. It's a tempting to determine the effectiveness of SANS countermeasures. For example, does lower body negative pressure improve SANS signs?

Dr. Wilner:
You mentioned OCT and tonometry. Are there any other cool gadgets that you're able to get up to the International Space Station to help assess these conditions?

CAPT Brunstetter:
There is always a balance between medical necessity and operational requirements. And so we would love, for example, to send up an MRI device, but there isn't enough space, and it costs between $10,000 to $20,000 per pound to deploy, really, anything to the Space Station. So tonometry is a small handheld device, and OCT, if you see it in your eye care professional's office, it usually sits on a desk. The NASA engineers along with the manufacturer have been able to shrink down the size of that device quite a bit, and so it is up there. It is currently the largest SANS device that we have deployed.

Dr. Wilner:
For those just joining us, you're listening to Clinician's Roundtable on ReachMD. I am Dr. Andrew Wilner, and I'm speaking with Dr. William Tarver and CAPT Tyson Brunstetter from NASA about Spaceflight Associated Neuro-ocular Syndrome, or SANS.

Dr. Tarver, how do you sort out the cognitive effects of microgravity when astronauts may be suffering from space sickness or taking medications that make them drowsy?

Dr. Tarver:
A large proportion of our astronauts do adjust to the microgravity environment, and that adjustment, unfortunately, includes nausea and a motion sickness-like effect. We do provide medications at that time that can have some effect on their neurocognitive situation. And in short, the answer is we don't really tease out the effects, and then immediate arrival time on station there is so much newness to this unique environment. But the astronauts adjust to the environment over a 2- to 3-day period and then fully adjust with just moving around the station over a couple of weeks, and they do not experience operationally any negative cognitive effects. They do extremely challenging tasks, lots of research, and they are able to keep up with the workload. So, we do have a program called the Behavioral Health Program, and they do routine neuropsychiatric evaluations and they can tease out even more details than they do right now, but we're not seeing an effect once we get over this space adaptation syndrome, we call it, or it's a space motion sickness that occurs

initially. Things are looking good, and we depend on our behavioral health folks and their battery of tests which they perform on a regular basis throughout the mission.

Dr. Wilner:
Dr. Tarver, I imagine that astronauts are all in top physical condition, and they accept the risks of spaceflight, but I wonder, does it require a different psychology to face the risk of some yet-to-be-defined, long-term disability rather than the risk of some catastrophic accident?

Dr. Tarver:
I imagine it does, but it's pretty hard even for the astronauts to think that long-term. They have on occasion been known to say something like, "Doc, I'm worried about the rocket blowing up more than getting a cancer in 20 years." So that long-term condition no doubt affects these individuals, but it's not going to be the top of their concerns around the mission time. They have accepted this psychologically years before when they became an astronaut, so it's not their top concern during a mission. And I will say these are some very capable individuals. And again, our Behavioral Health Program does an excellent job evaluating individuals' psyche and their capability, really, to live in a tin can and tight confines with several other individuals. We must know that before they go on a mission. If it was just me and you are locked up with me, it's quite likely I don't have the psychological capabilities to not try to do something untoward. In other words, I'd go nuts if I were confined with individuals. I am not astronaut material. Our BHP program is a very robust program, and they do an excellent job of finding these astronauts, these individuals who are just very well adapted psychologically to live in the challenging conditions of a space mission.

Dr. Wilner:
And, turning to you, now CAPT Brunstetter, do you think that problems like SANS will seriously impede long-duration spaceflight in the future like a trip to Mars?

CAPT Brunstetter:
Well, I think in a nutshell no one knows, including us. We don't know the potential impact of some of these risks. And as I mentioned previously, NASA's Human Research Program is tackling 34 of the top spaceflight risks to astronaut health—SANS is among those—and so a lot of effort is being placed into trying to mitigate these risks and also define countermeasures. From a SANS perspective, again, we can't predict what impact it will have, if any impact, during an expeditionary Mars mission, for example, but currently, we do know of 3 main risks associated with SANS. And I do want to stress that luckily, so far no astronauts have experienced any permanent loss of visual function during a 6-month mission on board the ISS, so this is very important to mention. But the 3 main risks that we have now are the same main ones that we would have going to Mars.

So the first one is globe flattening. If you take a look at an MRI of a postflight astronaut, this occurs in almost a third of long-duration astronauts, and it is a physical flattening of the back of the eye. And you could imagine that changes the geometry of the eye, and it concurrently shifts the astronaut's refractive air. Luckily, these changes have had no mission, vision or health impacts, and they shouldn't as long as you have a proper prescription eyeglasses or contacts that you can wear to correct the eye for that different shape.

So the second risk for SANS are choroidal folds—that is wrinkles in the back side of the retina—and they lay near the photoreceptors. So you could imagine if you've got old school 35 mm camera film, if you wrinkle that and then use it in a camera to take photos, the images that result from that would be distorted. Well, luckily, we have never seen any of that visual distortion that you might expect by having wrinkles in the back of the retina. However, it has the potential to impact it if the folds are in the right place. So, in theory, these folds, they could potentially reduce an astronaut's vision to 20/40 or 20/60, and importantly, this distortion would not be correctable by glasses or contact lenses. Again, we haven't seen this yet, and we hope we never will, but it is a possibility.

And then third, as Dr. Tarver has mentioned, optic disc edema. This is the main sign of SANS that we're concerned with, and it occurs at some level in nearly all long-duration astronauts, from very, very little to significant amounts. And this amounts to edema of the central nervous system, and, therefore, just like a lesion of the spinal cord or the brain, it could induce a permanent loss of neurons depending on the edema severity and its duration, so this is concerning given that a Mars mission will be approximately 3 years. But again, so far we've seen no permanent impact to the eyes from any of these signs, including optic disc edema. However, we have detected some temporary blind spot enlargements in at least 1 crew member during a long-duration mission, and again, for these reasons, that's why we're quite concerned about optic disc edema during a multiyear mission.

Dr. Wilner:
I just have one more question for you both. It seems like we're on the edge of space tourism. Tickets are still too pricey for me, but I'd like to go. Are there any health concerns that I should consider for a brief suborbital flight or maybe a weekend getaway at the International Space Station? CAPT Brunstetter, let's start with you.

CAPT Brunstetter:
Well, I guess my first question is: Where do I sign up? (laughs) I would not hesitate to take that weekend trip to the ISS. Although, Dr. Tarver mentioned the early issues are typically associated with nausea, so it might not be that comfortable for a short period of time, but Dr. Tarver, I think, is best to answer this question.

Dr. Wilner:
Dr. Tarver?

Dr. Tarver:
Yes, your short trip, I don't think you have to worry about your eyes, so that's the good news. That seems to set in weeks or months down the road. But the space adaptation syndrome will be your main challenge if you spend any length of time, so more than that 5-minute suborbital flight, which is what many of the early touristy tickets will get you; but if you try to stay for the weekend, it could be an uncomfortable weekend because it takes 2 or 3 days to adjust to the microgravity environment.

Dr. Wilner:
Well then I hope you guys are working on a solution to that problem too. (laughs) Well, Dr. Tarver and CAPT Brunstetter, it's been a real privilege to speak with you about this new neuro-ocular syndrome and the health risks of spaceflight. Thank you both for sharing your insights and experience with us today.

Dr. Tarver:
Thank you for having us.

CAPT Brunstetter:
Thank you very much.

Dr. Wilner:
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