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I am here to talk about my experience as a flight surgeon. I've been at NASA since 1991; I've worked on over 25 shuttle missions and recently completed the work on one of the long expedition missions, which Garret Riesman was on. I want to talk about taking care of people in a very unique environment called weightlessness. I also want to talk about taking care of some of the healthiest people in the world, we take some of the healthiest people in the world, put them in one of the harshest unique environments you can think of, and that's 240,000 miles away, on the Moon in a vacuum of Space, where it can be a positive 240 degrees Fahrenheit here and negative 240 degrees Fahrenheit there, and we ask them to run around in a dune buggy.

I come to you from the Space Medicine Clinic in NASA Johnson Space Center and we take care of astronauts. The number 1 job is mitigating risk, or prevention, as aerospace medicine is preventive medicine. My other specialty is primary care medicine, but preventive medicine means making sure that you have very healthy astronauts who will be career astronaut for 15 or 20 years, because we invest so much money in their training and by the time they are well trained we need their expertise to go back and back to space, and Garret is an illustration of that. And secondary, if they are asymptomatic and we can catch a disease early, then we can eradicate that disease or stop it in its process; if they become symptomatic, like a cosmonaut who had a heart attack two months before flying in space and we've had some close calls which I'll talk about.

We've had three evacuations from space stations, one was for intractable headaches, probably secondary to environmental causes, CO₂; we've had a urosepsis, secondary to a prostate infection that caused an evacuation and we had a heart problem that brought a crew back early. We've had fires, multiple fires and some second degree burns, as well as kidney stones, hypothermia during space walks; we've had psychological stress reactions, space walks depressurizations in toxic atmospheres. Fortunately we have never had an evacuation or the need to have one on a shuttle mission, but mostly when they first go up into space what you are going to see is space motion sickness or space adaptation sickness, and almost all of them have some of these symptoms because the fluid shifts upward, the vestibular system, the neuro-vestibular system has to adapt.
In space you lose about 1-3% of your bone mass because you are floating. Your calcium normally stores in your bones, loading bone mass, but after a month in space, where is that calcium going? It's going through your kidneys, so we are really concerned about kidney stones and it's been a problem in space but also after landing, when they are very dehydrated and that perpetuates the formation in your kidney to form a kidney stone. The other problem is that since it's a very enclosed environment, we can't carry an emergency room up there, although we're trying to do so. It was one of my first projects, trying to develop an emergency medical system for the space station, we've come up with something, but basically if astronauts get really sick and they have to come home, if their brain tumor shows up, if they get appendicitis, we can get them home in about 24 hours from the space station! We can get them back from the Moon, but it may take as long as seven days! From Mars it's going to take probably over a year, so you're going to have to have incremental increases in medical capabilities and stand-alone medical care in robotics, in telemedicine capabilities.

Representatives of all six partners in the international space station comprise a multi-lateral medical panel that decides who is qualified to fly into space, so everyone that flies has to go through our medical board. It's an exciting time in medicine because many of the folks we would have had to have grounded or disqualified, for instance for fibrillation which predisposes someone to forming a clot and throwing that clot to the lung, we can now cure. With two astronauts we've been able to go in and actually oblitate those bad nerve fibers in the left atrium and cause them to be cured - it's called reflation therapy.

Our job is to have astronauts and cosmonauts free from any medical conditions that would compromise the mission objectives, which would have to interrupt the mission. More importantly that would compromise their health and safety, not just while they're associated with the mission or while they are in a career, but also later, after they've retired from the Corps, and we follow them throughout their lives offering surveillance to make sure they have a long life and that we are doing the proper occupational surveillance of their medical condition.

We now scan everyone with MRI/MRA technology. This has been a boon for us, we've actually found an aneurism. One astronaut we treated unfortunately had a malignant tumor that we found, and you can't do a lot about that but we found two benign tumors and we've been able to surgically take care of them and one of those astronauts is about to go into space in the next couple of years.

I have to say something about coronary diseases because I come from Houston Texas, the second most obese city in our country and because 50% of the population in our country will probably die of a heart attack. I want
to talk about how we screen our individuals. We have some healthy individuals but sometimes we just don't know what the situation is in the coronary arteries.

It was always thought that the coronary arteries were just clogged up with cholesterol. Well, actually we now know that it's an inflammatory process probably caused by bad cholesterol getting together with some immunologic macrophages or it makes immunologic goo, and it's not necessarily in the lumen itself, in the hole of the artery but outside the artery. Also, as it forms, calcium will eventually form and that helps us find early coronary disease for very small amounts of money.

We use an intra-coronary ultrasound, an ultrasound device that goes through, inside the coronary arteries and can map what the arteries look like on the inside; we've been doing this over the last five years, working with some of the top folks in this field. For $250 you can get electron-beam CT scan of your heart which gives you the same radiation as a mammography. If we find calcium when people are actually applying to the Astronaut Corps, in their thirties, we will not accept them. If we find it in a small amount - in the Corps we have four people who we found this on - we can intervene with medications and stop or arrest this progression hopefully. If they have a bigger amount of calcium, unfortunately they will not fly in Space. We try to catch it early, because then we can intervene with diet, exercise and medication. Our job is to keep them flying; in fact John Glenn flew in space for the second time on the shuttle at the age of 76.

I had the great fortune of working with the 107 crew, and I was assigned to this mission about three years before it went. This mission is one of the busiest to date. We get to train with them, we do water-survival training, and we fly in the T-38 jets. We train them in medical procedures, we train them how to do emergency medical procedures: for a long duration in Space you get approximately 100 hours of training; for shuttle crew medical officer training you get about 15 hours of training. But we actually have a small emergency room with the ability to intubate, defibrillate and give many different medications. Not only do I train them how to do this on the ground, I also train them how to do it in weightlessness, which is a very different thing. The astronauts train under water to simulate space flights. They work in virtual reality labs; they also work in Russia doing a similar task.

At the Kennedy Space Center we get ready for the launch, and the medical forces are in charge of the emergency medical plan both at Kennedy and also at the transatlantic abort sites: in case they lose an engine on the way up, they may end up in Spain or France. The other thing we do when they go to crew quarters is to quarantine them for seven days so that they won’t get the flu, or a bug or any problem, to ensure that when they launch into space they are very healthy.
The other thing we've pioneered is actually using bright light therapy and melatonin therapy to help shift people's circadian cycles. It has been very successful so that when they launch they have already shifted to their rhythms up in space. After they launch, I get in a T-38 or an STA craft, a NASA craft and I fly back and hopefully get back in time to do a medical conference with the crew; we do a private medical conference every day on the shuttle missions. On the long duration missions it's the first 5 days and then they usually get acclimated to space and after that we talk to them weekly; but we also monitor mostly the environmental systems of the space station, the CO2 levels, the radiation levels, and we really don't look at their EKGs until they are doing space walks, and if they get out there for more than 6-6.5 hours, we have to sort of sign in there that it's OK.

The space craft itself is an isolated system, and we have to worry about noise and vibration; it's a closed-loop environmental system also working on payloads in the construction of the space station, so there's a lot of mass being moved around and we worry about trauma.

Space motion sickness is when you go up in space, and cardio-vascular problems arise when blood shifts upward with weightlessness', goes to my head, and tells my carotid bearer receptors that I have too much fluid and I should relax and get rid of it. So I get rid of it, I urinate it off and then that's OK while you're up there, but then eventually you have to come back to Earth. When you come back, you are down by about 1 or 2 pints of blood, which we can try to replace with a fluid loading protocol and we put a G-suit, a lower body G-suit on their lower extremities to try to get the blood up so that they don't pass out when flying the shuttle back.

There is no standing up and sitting down in space, so you've been sitting for a while, if you stood up very quickly there will be less blood flow to your carotid bearer receptors, so it would go: "wow, I need some more blood to my brain", telling the heart to beat faster, and the arteries to constrict in order to get blood to the brain. Well, if you are not doing that for days or months you lose that receptor sensitivity, so when astronauts first come back, they may not be able to mount a blood pressure response for hours, and sometimes for as much as a day, that's a real problem for us. The other is muscular-skeletal, every morning when you wake up you are 1-2 cm taller than when you went to bed, and so you unload your spine, and up in Space there's no longitude, no pressure, unless you do resistive exercise devices, as counter-measures. Consequently, their back elongates and the muscles of the back elongate and they have back pain for the first week or two in space.
I mentioned the bone loss, the calcium loss, and we worry too about kidney stones, and our crew's health environmental system. We take care of the medical care, the medical kits, the medical equipment and deal also with environmental health. Our counter-measures in Space include the treadmill.
I also want to talk about psychological aspects, a real problem for us – mood swings, moral changes, being away from family, the workload is intense, sleep is very difficult in Space; crew personalities can sometimes be a problem when one crew leaves and then another crew joins us. We are about to go to 6-person crew and that should be interesting. We actually have two staff psychologists and two staff psychiatrists in Johnson Space Center to help us with these things.

Sleep is needed, and it's hard to get when you have sunrise and sunset every 45 minutes, since the shuttle is traveling at 70,000 miles an hour! It's hard not to look out the window, and it takes a while to get used to sleeping, it takes different configurations of how you want to sleep, but eventually they manage to sleep. Sleep is very important, actually it's the number 1 medication up in orbit, and you don't want them fatigued when they have to fly this to orbit or back, and up in the space station.

On average they lose about 5% bone density over the course of the lumbar spine and the hip, but some people lose as much as 15% over the course of 3-6 months up in Space. The good news is, and the good news for all of us is to keep exercising and do resistive exercise, that's how they get it back over the course of one to two years, some people do very well and some people don't do as well, and it would be nice to know who those people are so that we can intervene sooner rather than later. As to their aerobic capacity, their capability to exercise when they first get up to the space station is of course much lower by about 20%, but as they get used to the space station, the environment and their exercise capabilities, they get back close to only 10% and then when they land they come back to normal, which is good news.

The neuro-vestibular system is the most sensitive and the one we really worry about, takes up to 14 days, that's the longest it's taken anyone. We put them on a platform that moves them and they have to trek, and that takes about 14 days.

Finally, let's talk about the Sun and the solar flare. Why don't we get pickled when we have solar flares? That's because the Earth has an iron core and right now relative to the center, we are traveling at 1,000 miles an hour, we're about 24,000 miles in circumference and it takes 24 hours in a day, and so that generates, because of our iron core, a force field, a magnetic field which protects us. These force fields come at the top of the Earth like a magnet, and that's where the aurora borealis and aurora australis, the northern and southern lights, show up. But unfortunately that holds only for about 4,000 miles out and if you are going to the Moon or Mars there's no protection, which is why we are really concerned about DNA damage, especially if we are going to Mars.