SURGERY IN SPACE: SOMEBODY NEEDS TO FIGURE IT OUT | BY ELLEN KRUCZEK

REALLY OUT THERE

Where does humanity push its limits? You might think deep space travel or maybe medical interventions capable of bringing us back from the brink of death. Sandip Panesar, an MD pursuing a postdoctoral research fellowship in the University of Pittsburgh Department of Neurological Surgery this year, thinks both. He uses his role as a researcher to work on, as he says, "weird papers." The physician was interested in neurosurgery in space, but found that even the basics of general surgery in that context were not laid out. So he published a review in the *British Journal of Surgery* in June to explore the potential issues and solutions a surgeon might encounter. He says, "The thing is, nobody knows anything about [surgery in space]. What I was trying to do, the whole point of the article, was try to open up a discussion."

When astronauts need medical attention on the International Space Station, they are sent back to Earth. However, if SpaceX, NASA, and other organizations realize a human mission to Mars, interventions will need to happen in space.

Panesar's review highlighted the well-known effects of prolonged time in orbit on the human body. We know that astronauts are vulnerable to a loss of bone and muscle mass, plasma, red blood cells, and immune function. We weren't built for low gravity, recycled air, or being stuck in enclosed spaces 24/7—or whatever the length of a day would be in a shuttle hurtling away from here. (At least a solar day on Mars is about the same as it is on Earth.)

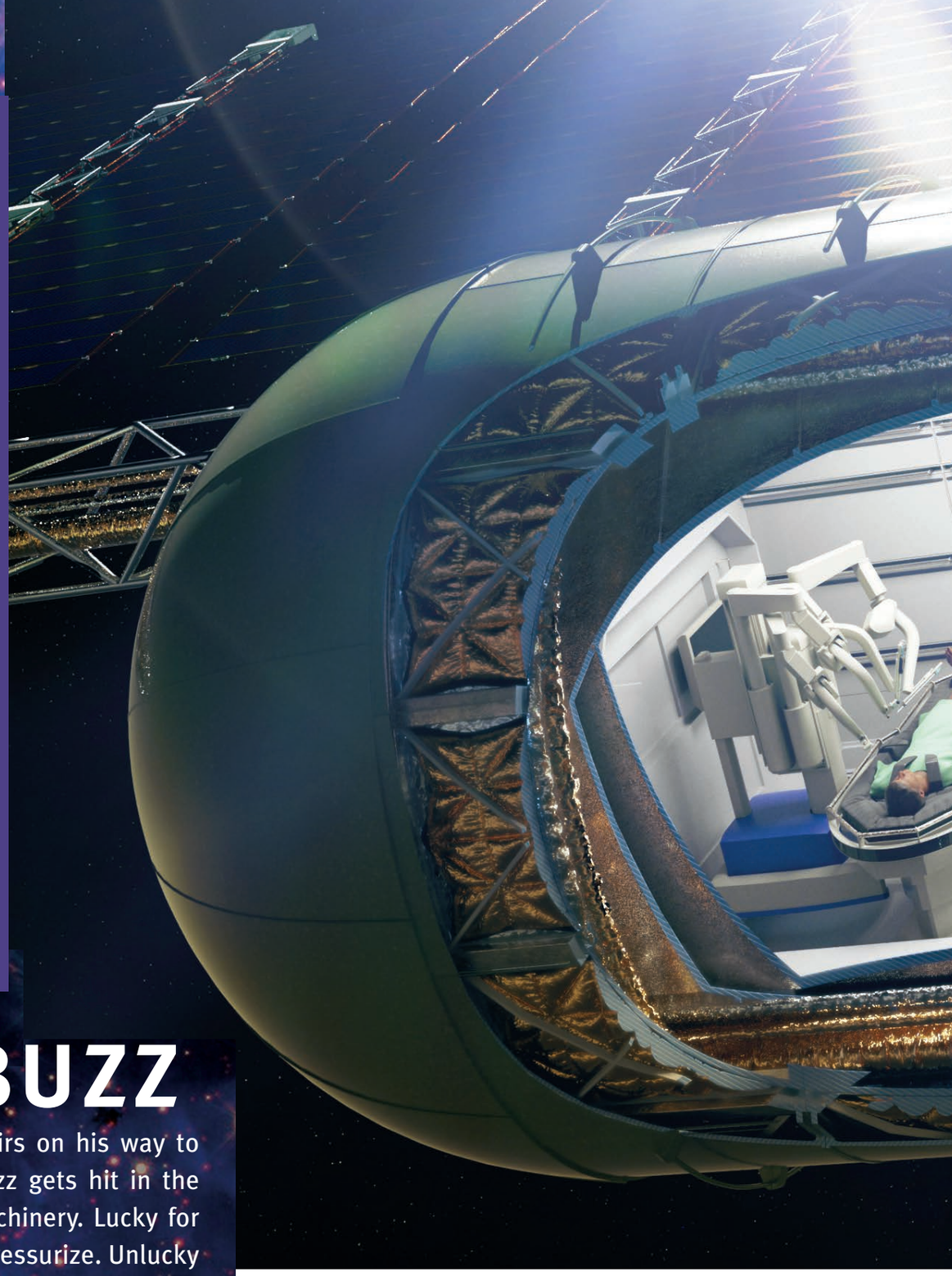
Floating entrails, cramped quarters, no FedEx . . . How will we take care of seriously injured people when they're millions of miles from here?

MARS IMAGE COURTESY NASA

A long-term Mars mission would expose astronauts to more radiation, as well. In space, people experience an increase of fluids to the head and mental strain; they also up their odds of getting cancer.

Panesar explored medical crises that astronauts are most likely to encounter, notably blunt trauma. He frames surgery within that context, tackling the limits of the current protocols for trauma care. Some issues don't have easy answers. For example, bottled oxygen is in every hospital emergency department, but it would create an enormous fire hazard in a closed shuttle. Regardless, Panesar sees space flight medicine as an inevitable, rather than an accessory, field. Panesar, who recently accepted a fellowship at Stanford University with Pitt Med fellow alum Juan Fernandez-Miranda (Fel '10), is now tackling the limits of neurosurgery in space.

When asked why his interest led him to address bodies celestial, he says, "Don't we all have that sort of interest? If someone said, *Do you want to go to space?* what would you do?"



SAVING BUZZ

Let's say that while making repairs on his way to Mars, flight engineer Bluford Buzz gets hit in the abdomen by a loose piece of machinery. Lucky for him, his suit didn't break and depressurize. Unlucky for him, he's 13 million miles from Earth. How would his treatment differ in space versus on Earth?

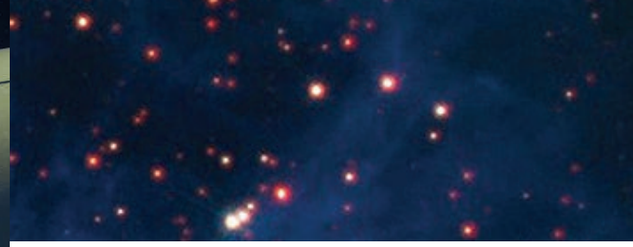
Scenario: Buzz might have internal bleeding from his injury.
On Earth: To look for free fluid in the abdomen, a doctor uses sonograms to check for where fluid may be gathering. This technique is called FAST.
Problem: The doctor might not be sure where to look for free fluid in Buzz. Fluid disperses differently in microgravity and might not collect in expected areas.
Solution: Researchers are exploring 3-D FAST approaches that could be effective in microgravity.

Scenario: Buzz might experience depressed airway muscle function or hypoventilate.
On Earth: Intubation is sometimes used to protect an airway and keep patients breathing.
Problem: Buzz is more likely to need intubation in space, as microgravity strains the cardiovascular system and, in turn, the respiratory system. Yet, microgravity also draws fluid to the face, so Buzz will have facial swelling. This makes intubation more difficult.
Solution: New methods could help. The i-gel, for example, which is used internationally and which Pittsburgh EMS will be adopting, creates an upper passageway guide for more complex intubation.



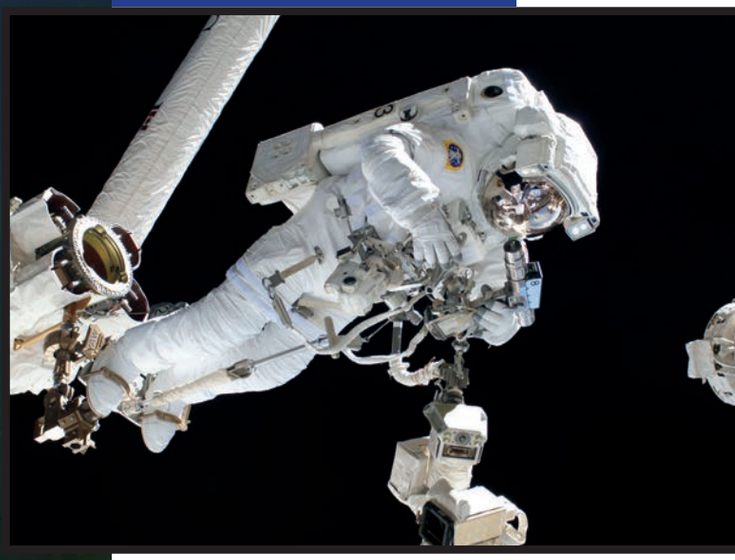
Both the physician and the patient are strapped down in this imagined trauma pod.

ILLUSTRATION BY T. TRAPP/PLANVIS
COURTESY JOHN WILEY AND SONS PUBLISHERS



Consider the gravity of the situation if a space walk were to go wrong. BELOW: European Space Agency astronaut Luca Parmitano has some idea. In 2013, an equipment malfunction caused his helmet to fill with water.

IMAGE COURTESY NASA/JOHNSON



Scenario: Buzz's doc needs specialized equipment to treat him.
On Earth: In developed countries at least, surgeons have access to vast hospital resources. They're also able to receive shipments.
Problem: NASA estimates it costs $10,000 to send a pound into orbit, so the Mars mission has packed light. There are no delivery trucks headed into deep space toward Buzz.
Solution: Onboard 3-D printers make the necessary tools for Buzz's procedure. He'll need a lot of fluids, so do-it-yourself saline mixes could do the trick—just add sterilized water.

Scenario: Buzz is bleeding heavily.
On Earth: During surgery, blood is contained in the body or falls to the ground, where it's mopped up.
Problem: In microgravity, Buzz's blood separates into droplets. His blood (and intestines!) would be free-floating, creating more problems for Buzz and a biohazard on the shuttle.
Solution: His space surgeon might be able to use a sealing system to keep Buzz's insides, well, inside. James Antaki is developing hermetic sealing for spaceflight and the military. Antaki is a Pitt PhD adjunct professor of surgery and bioengineering who recently joined Cornell University.

Scenario: Not enough space in space.
On Earth: A surgeon uses an operating room to hold patients and surgical materials.
Problem: The cramped shuttle would not be able to dedicate cubic footage to anything like what a typical OR requires. Further, neither Buzz nor the surgical materials would be contained in microgravity.
Solution: A trauma pod, like one being developed at SRI International, could strap down and contain Buzz and required materials. It would also create a specialized, compact area for procedures.

Scenario: Buzz's doctor isn't sure what's wrong with him.
On Earth: The hospital has many specialist physicians and resources for critical care. If needed, they can also do telemedicine consults.
Problem: Radio waves take 13 or more minutes to reach Mars, and that limits the usefulness of specialists calling in during an emergency.
Solution: An emergency medicine physician with combat surgery experience would have a wide enough skill set to stabilize Buzz. For other surgeries, autonomous robotic surgical arms could fill some expertise gaps. This technology is still under development for critical care, but fully autonomous bots already perform dental implants in China. ■