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Lab Medicine in Space
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Guest: Dr Saswati Das is an Assistant Professor and Senior Specialist in the Department of Biochemistry, Atal Bihari Vajpayee Institute of Medical Sciences, New Delhi, India.

Bob Barrett: This is a podcast from *Clinical Chemistry*, a production of the American Association for Clinical Chemistry. I'm Bob Barrett. With increasing focus on space exploration and the advent of space tourism, there is a need to diagnose disease and conduct research in a very different environment from what we've been used to on Earth. The recent introduction of point-of-care testing on the International Space Station has prompted a whole host of new questions that must be answered in order to establish a successful laboratory testing program. Are reference intervals different in space? Is the stability of quality control materials and assay calibrators affected by space travel? Do laboratory instruments perform the same way in space as they do here on Earth? How can instruments intended for use in space be condensed into the smallest possible footprint.

A Q&A article appearing in the May 2023 issue of *Clinical Chemistry* explores the new and growing field of laboratory medicine in space, discusses unique elements of the microgravity environment that make testing challenging, and identifies opportunities for laboratorians to support future space travel.

In this podcast, we are pleased to speak with one of the moderators of that Q&A session. Dr. Saswati Das is an Assistant Professor and Senior Specialist in the Department of Biochemistry at Atal Bihari Vajpayee Institute of Medical Sciences, New Delhi, India. Along with her work in terrestrial laboratory medicine, Dr. Das is also active in the field of diagnostics in space. So, Dr. Das, give us a general overview of the scope of lab testing in space.

Saswati Das: Yes, Bob. So, this is a really interesting topic I like to speak about. Long-term travel and short-term travel to space are becoming more and more common and the concern for human health and safety in space is also expected to grow as the travel increases. There are many challenges that humans will face in this quest for space. As the risks increase, there will be a need to diagnose the physiological impact on the astronauts. Laboratory testing as of now is available for astronauts on space, on board ISS. So, if we want to list out the analyzers that are available, there is an i-STAT analyzer that is available on board, there is a centrifugation that is available, urinalysis strips are available. PCR and sequencing have also been tried out on ISS.

With this data generated from the study and the Inspiration4, space omics has emerged as a field of research itself and there are also many molecular diagnostic studies which are going to be conducted in future missions like Polaris.

However, I would like to point out something that pre-analytical procedures like aliquoting, filtering, centrifugation, they pose a significant biological hazard on board.

In the extreme conditions of space, there are a lot of operation challenges as well. The reagents supply is a significant concern and the payload cost which is very high also has to be kept in mind. The hardware, as you know, would undergo extensive testing to be able to withstand the launch temperatures. So, the major concerns on board are the availability of biological replicates, preserving the sample integrity, and prevention of the contamination.

Bob Barrett: What advances in laboratory testing are required to better support future space missions?

Saswati Das: Improving our capacity to analyze and process samples from various sources will be essential in guaranteeing the long-term success of space exploration missions. There will be need of a single compact device which will be simple to use and can be deployed in a constrained area as missions transition from ground-based to deep space missions. This instrument should ideally be able to process unaltered rapid analysis and be used for a variety of sample types, such as breath, saliva, tear.

Future mobile device technology will also be crucial including innovations and sensors to monitor vital signs, cameras, video recorders, and medical necessities for smartphones. These devices require little training and have user-friendly interfaces. By putting these technologies into practice, we can learn a lot about the health risk posed by space travel and also the discoveries will help us improve both the space exploration and improve life in remote areas.

The emerging technologies like microfluidics, mobile wire sensors, diode lasers, magnetics operations, are likely to be instrumental in designing miniature flight analyzers. Artificial intelligence enabled self-driving labs may be used in future missions. All said and done, these technologies should be further evaluated if they’re safe and effective in spaceflight environments.

Bob Barrett: So, what are we getting from this? What can you tell us about the quality of data generated by spaceflight lab tests?

Saswati Das: The one key takeaway is to generate quality data is that all samples must be processed using the same procedure in order to maintain quality assurance integrity. It also helps if the samples are processed by the same individual. This would guarantee that the same processes would be followed consistently. Additionally, one core facility should be backed, the samples are handed in accordance with SOP for post-processing of tissues and blood samples.

A good example of this is the NASA Ames team, who have created high quality reliable data that they have made accessible to the public on an open platform. They consistently prepare tissues for RNA sequencing and the results from various missions can be accurately compared. The integrity of samples can be protected using specific chemicals. For example, maintaining samples for imaging with formaldehyde and maintaining samples for molecular based tests with DNA and RNA stabilization reagents.

One of the best strategies for sample preservation remains to be rapid freeze. Data validation can also be done in number of phase. One very clever strategy is to uncouple the experimental blood draws to the mission time and couple it to the timing of vessel egress from the ISS to the earth. This approach has benefited from synchronous blood draws on earthly controls where the samples are kept under similar temperature conditions as the space samples. And coming to accreditation, all CAP accreditation protocols are followed at the NASA Johnson Space Center.

In a recent evaluation of a small commercial hematology analyzer on board International Space Station, standard laboratory commercial controls were flown. And it was discovered that some degradation had taken place between the time of launch and the flight evaluation. For missions to deep space, this issue becomes considerably more severe. It is likely that deep space quality assurance cannot be carried out with the same rigor as a routine laboratory on Earth and hence, a quality plan adapted to space conditions will be necessary to achieve the monitoring needed.

Bob Barrett: So, is it reasonable for us to anticipate that laboratory medicine specialists will play a key role at upcoming space missions?

Saswati Das: Yes, definitely. Microgravity environment causes a number of physiological changes in astronauts. Interpret these different changes occurring to the organs, knowledge in lab medicine is a must. The lab experts' interpretative skills are crucial for research experiment as well.

There is a program that is coming up by the NASA's Division of Biological and Physical Science, which is known as the Commercially-Enable Rapid Space Science (CERISS). So, it will send highly specialized scientists into space to undertake research that even the best trained astronauts will find challenging.

Similarly, Orbital Reef, another one of the upcoming commercial space stations, is putting forth a similar plan in which trained astronauts in specific fields will receive training in manufacturing and scientific research.

So, these programs tell us that there will be a need for knowledgeable and multi-disciplined space lab specialists to perform research and monitor astronaut health in the near future.

Pre-flight medical laboratory and behavioral training is a crucial component of astronaut medical treatment. Because of training in disease pathophysiology, a pathologist is knowledgeable in a spectrum of disease manifestation. A pathologist can quickly begin follow-up with a small departure from normal in comparison to an individual's prior laboratory test results, which can be observed in very healthy astronauts also.

Bob Barrett: How can trainees prepare themselves for future roles supporting lab medicine in space?

Saswati Das: There are currently a number of programs providing residencies in space medicine and more academic programs are expected to be offered in the near future. The demand for space medicine specialists will only increase as more and more commercial spaceflight programs give participants access to space travel.

It is time for space lab medicine to claim the widespread acceptance because it would enhance student education in many ways. The specialized training will make it possible to comprehend the pathophysiological consequences of human exposure to this extreme environment, in which mostly all systems are impacted.

Soon, space medicine will no longer be limited to the space agencies of selected countries. Other than professionally trained astronauts, space tourism will extend the impacts of space exposure to other groups as well. Pre-flight screening will be necessary for conditions that are likely to be impacted by space. Medical issues in orbit and following return to earth will necessitate proficiency in test result interpretation, requiring an increased expertise in the field of space lab medicine.

So, I believe a rotation in space lab medicine for the lab medicine trainees and pathologists will increase the exposure of this specialty to the trainees. Also, undergraduates should be made aware of the diagnostics in space by giving them an option of an elective.

Bob Barrett: Well, finally, Dr. Das, let's look ahead. Give us a preview of what the future holds for specialists in space laboratory medicine.

Saswati Das: A space lab medicine specialist, if on a mission, may not only have to have exceptional scientific knowledge, problem solving skills, and a strong work ethic but is also expected to hold a number of key social qualities. These abilities include the capacity to work well with teammates and be effective in microgravity settings. They also include the capacity to work well under pressure and multitask. Although it is obvious that having emergency medical and laboratory skills as advantages, deep space missions might not necessarily include a lab medicine specialist. Therefore, user-friendliness of deep space laboratory equipment, as well as general pre-mission instruction, will be crucial.

There are many types of payload that do not require pre-mission training. Increased automation will enable efficient analysis of samples and reliable production of data, both in orbit and on earth. Additionally, building automated miniaturized sequencing capacity for future missions will be critical. Expanding omics technology to more sophisticated levels will increase knowledge for post-processing on Earth. Proteomics and RNA sequencing will be excellent next steps.

Bob Barrett: That was Dr. Saswati Das, from the Atal Bihari Vajpayee Institute of Medical Sciences, New Delhi, India. She moderated a Q&A session on lab medicine in space in the May 2023 issue of *Clinical Chemistry* and we are pleased to have her as our guest in this podcast on that topic. I'm Bob Barrett. Thanks for listening.