Remote Cardiac Monitoring in the Internet Age

Dr. James Thomas has conducted research with NASA on improving remote monitoring and diagnosis of the cardiovascular system, bringing insights from his expertise in clinical echocardiography. His work on the live transmission and digital storage of echocardiographic data has immediate applications to both the International Space Station and Earth-based clinical medicine and telemedicine.

If an astronaut experiences a medical emergency while inhabiting the International Space Station (ISS), the nearest emergency room is 221 miles away back on Earth. With the need for medical professionals to monitor astronaut health and provide advice and instruction in an emergency situation, NASA is working to improve techniques for the remote diagnosis of medical conditions and transmission of medical data.

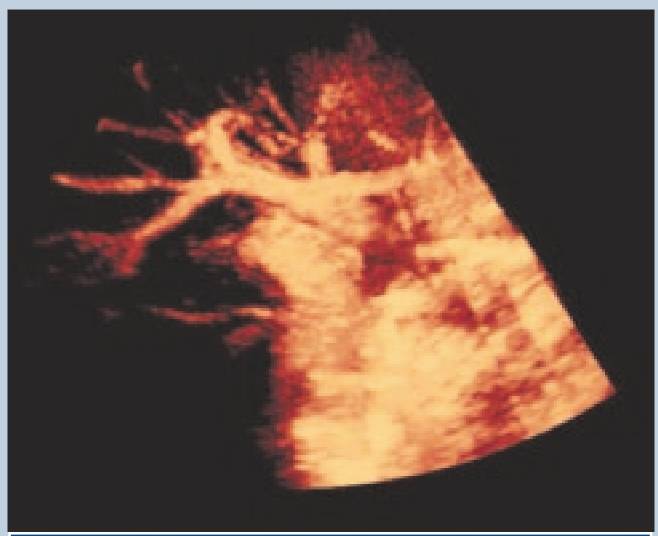
One such technique is echocardiography—the use of ultrasound to examine the structure and function of the heart walls and valves. The ability of physicians on Earth to view real-time echocardiograms of astronauts will provide a valuable tool to diagnose medical emergencies in space. In addition, this technology will greatly assist scientists in meeting NASA's goal of understanding how long-term exposure to microgravity affects the cardiovascular system, and it opens exciting opportunities for use in remote locations on Earth.

Optimizing Storage and Transmission of Echocardiographic Data

Dr. James Thomas, Director of Cardiovascular Imaging at the Cleveland Clinic Foundation, has been working on space applications of remote cardiac monitoring for the last four years. He was drawn to the NASA research when he first became aware that a clinical, high-quality echocardiograph would be launched to the ISS.

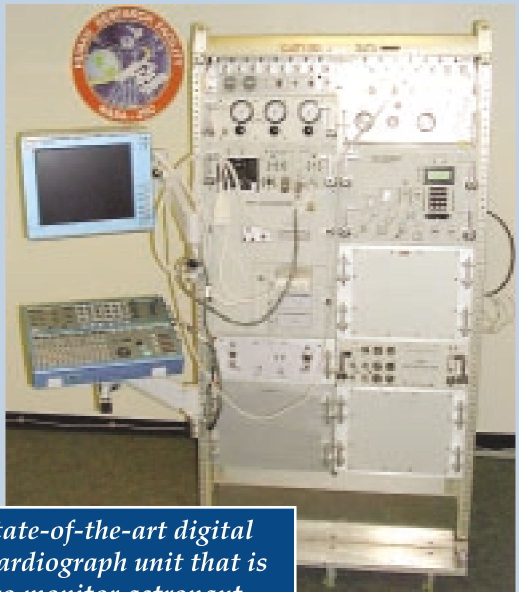
His central research focus is the diagnosis of cardiac disease through clinical echocardiography. As part of this research, his laboratory has been helping to move echocardiography into the digital age, using digital equipment, Internet data transfer, and real-time sharing of echocardiographic images over high-speed data networks. The storage and transmission techniques they have developed will be put to use in medical monitoring on the Space Station.

One drawback, however, is that ultrasonic imaging creates an enormous volume of data, and learning to manage these large quantities of data presents a major technological challenge. Getting echocardiographic images back from space—or transmitting them on Earth in clinical settings—requires the resolution of several complex issues. Electronic files are often compressed to reduce their size for purposes of storage and transmission. However, different compression techniques, and the amount of compression applied, can affect the quality of digital images. For video files, transmission speed is also critical: certain minimum transfer speeds must be maintained for streaming video to be useful in a clinical setting.



Echocardiographic images allow scientists to view heart function and structure without invasive surgery.

As data storage and transmission requirements for uncompressed digital echocardiographic images are prohibitive (up to 220 million bits of data per second), Thomas's group investigated "what we can do to compress these images, how we can use wireless and fixed cable communications to move images around, and how much compression is acceptable from a clinical diagnostic point of view."



The state-of-the-art digital echocardiograph unit that is used to monitor astronaut health on the ISS.

JPEG, a standard for compressing photographic image files on the web, has been accepted as the standard for the imaging format adopted by the medical and manufacturing community. This is the compression method that will likely be used for ultrasound studies conducted on the ISS. To test this methodology, Thomas and colleagues have implemented the largest digital echocardiography lab in the world. As a possible successor to JPEG, his group has investigated MPEG compression, which offers higher image quality at the same compression rate and opens up the possibility for real-time transmission of echoes to the ground to permit immediate diagnosis and guidance from ground-based experts. They successfully tested this technique on streaming echocardiographic images sent from the NASA Glenn Research Center in Cleveland to Ames Research Center in California over the NASA Research and Education computer network.

Exciting Possibilities on Earth

Back on Earth, echocardiography is the most common cardiac imaging test performed today. The health care industry is, therefore, very interested in ways to increase the efficiency of performing and interpreting the test. Digital echocardiography offers significant savings in storage space and physician review time and provides greater diagnostic accuracy, compared with images stored on traditional analog videotape.

The ability to view live digital echocardiographic data over a computer network opens up exciting possibilities for telemedicine applications to clinics located far from major hospital centers. Physicians at remote clinics seeking advice from a specialist could acquire real-time input on a patient's health. Thomas and his colleagues have observed and advised remotely on cardiac surgery using this technology. They have also experimented with remotely guiding inexperienced users through the steps of operating an echocardiograph, an issue of paramount importance for space application as the crew will never have the training required for mastery of all aspects of diagnostic ultrasound.

Thomas recalled, "We did a test to see if we could take people who essentially have very little training in ultrasound and give them a crash course in how to hold the probe and turn it on, and then provide guidance through a video link. We showed that with just four to eight hours of classroom orientation, we could get diagnostic images when a trained sonographer remotely coached the person through the examination. This is one of the models that we're able to use with the astronauts, who are not going to be as highly trained as our sonographers or physicians."

Thomas and colleagues at NASA's Johnson Space Center have even experimented with remote guidance and interpretation for a simulated Mars mission. Ultrasound images acquired with a small portable device at the Devon Island Mars Habitat Site in northern Canada were successfully digitized and relayed via geosynchronous satellites to JSC. "Even under these extreme conditions, the images were of consistently good quality, and we showed that we could coach the on-site personnel to get supplemental images that were helpful in finalizing a diagnosis."

This technology and teaching method could be of great use to clinics in remote locations. If staff with only one day of training can be guided through an exam by an expert at a medical center, who could then make a remote diagnosis using real-time data, the need for costly and inconvenient travel by patients could be significantly reduced. After all, many clinics here on Earth are farther away from a large medical center than the space station is from Earth.

References

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