Extreme Tele-Echocardiography: Methodology for Remote Guidance of In-flight Echocardiography Aboard the International Space Station

David S. Martin, MS, RDCS[1], Allan Borowski, RDCS, FASE[2], Michael W. Bungo, MD[3], Patrick Gladding, MD[2], Neil Greenberg, PhD[2], Doug Hamilton, MD[1], Benjamin D. Levine, MD[4], Stuart M. C. Lee, MS[1], Kelly Norwood[5], Steven H. Platts, PhD[6], Tim Matz, RDCS[7], Matthew Roper[5], Gwenn Sandoz[5], James D. Thomas, MD, FASE[2]

[1]Wyle Integrated Science and Engineering, Houston, Texas; [2]Cleveland Clinic, Cleveland, Ohio; [3]University of Texas Health Science Center, Houston, TX; [4]University of Texas Southwestern Medical Center, Dallas, Texas; [5]Lockheed Martin, Houston, Texas; [6]NASA Johnson Space Center, Houston, Texas; [7]MEI Technologies, Houston, Texas

Background: Echocardiography is ideally suited for cardiovascular imaging in remote environments, but the expertise to perform it is often lacking. In 2001, an ATL HDI5000 ultrasound system was delivered to the International Space Station (ISS). It was replaced by a GE Vivid Q in July, 2011. Both instruments have been used in a study to investigate the impact of long-term microgravity on cardiovascular function. The purpose of this report is to describe the methodology for remote guidance of echocardiography in space.

Methods: In the year before launch of an ISS mission, potential astronaut echocardiographic operators participate in 5 sessions to train for echo acquisitions that occur roughly monthly during the mission, including one exercise echocardiogram. The focus of training is familiarity with the study protocol and remote guidance procedures. On-orbit, real-time guidance of in-flight acquisitions is provided by a sonographer in the Telescience Center of Mission Control. Physician investigators with remote access are able to relay comments on image quality to the sonographer. Live video feed is relayed from the ISS to the ground via the Tracking and Data Relay Satellite System with a 2-second transmission delay. The expert sonographer uses these images, along with two-way audio, to provide instructions and feedback. Images are stored in non-compressed DICOM format for asynchronous relay to the ground for subsequent off-line analysis.

Results: Since June, 2009, a total of 27 resting echocardiograms and 5 exercise studies have been performed during flight. Average acquisition time has been 45 minutes, reflecting 26,000 km of ISS travel per study. Image quality has been adequate in all studies, and remote guidance has proven imperative for fine-tuning imaging and prioritizing views when communication outages limit the study duration. Typical resting studies have included 27 video loops and 30 still-frame images requiring 750 MB of storage.

Conclusions: Despite limited crew training, remote guidance allows research-quality echocardiography to be performed by non-experts aboard the ISS. Analysis is underway and additional subjects are being recruited to define the impact of microgravity on cardiac structure and systolic and diastolic function.