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Telemedicine Workshop Summary Report

Kristina Barsten
Project Manager, Exploration Medical Capability
Enterprise Advisory Services, Inc.
NASA Johnson Space Center Bioastronautics Contract

Sharmila D. Watkins, M.D., M.P.H.
Element Scientist, Exploration Medical Capability
The University of Texas Medical Branch
NASA Johnson Space Center Bioastronautics Contract

Christian A. Otto, M.D.
Telemedicine Consultant
Universities Space Research Association

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Acronyms

ARC	Ames Research Center
CMO	crew medical officer
EMR	electronic medical record
JSC	Johnson Space Center
NASA	National Aeronautics and Space Administration
NEA	near-Earth asteroid
OpsCon	Operations Concept
USRA	Universities Space Research Association
UTMB	University of Texas Medical Branch
VistA	Veterans Health Information Systems and Technology Architecture

Introduction

The Exploration Medical Capability Element of the Human Research Program at NASA Johnson Space Center organized the 2011 Telemedicine Workshop to bring together leaders in remote medicine. The workshop participants were asked to outline the medical operational concept for a crewed mission to a near-Earth asteroid (NEA) and to identify areas for future work and collaboration.

The objectives of the workshop were to document the medical operations concept (OpsCon) for a crewed mission to a NEA, to determine the gaps between current capabilities and the capabilities outlined in the OpsCon, to identify the research required to close these gaps, and to discuss potential collaborations with external-to-NASA organizations with similar challenges. The workshop deliverables are this summary report, the finalized medical OpsCon document, an updated telemedicine research plan, and a list of potential collaborations.

The following sections summarize the discussions held during the workshop and the conclusions reached by the workshop participants. These findings will be incorporated into the OpsCon document.

Crew Medical Officers

Workshop participants quickly recognized that the purpose of a NEA mission would be to conduct exploration, not practice medicine. Therefore, participants considered the need for resource optimization when making recommendations regarding the number and medical background of crew medical officers (CMOs). The more medical training time that is required of crew members, the less training time is available for other important mission tasks (such as maintenance of the craft and scientific research).

The participants stressed several broad, overarching points. First, the required level of crew medical training is inversely related to the communication and telemedicine capabilities on board. For example, the possibility of communication blackouts is a driver for increasing the medical skills of the crew. Second, if engineering controls can reduce the likelihood of medical events, these controls must be in place. Finally, each potential medical scenario should be carefully considered to ensure that diagnosis and treatment are feasible with a crew of 3, given that 1 crew member is ill or injured and that other mission tasks may need to be performed.

Participants recognized that, to date, space flight crews have not been required to have a physician crew member; however, participants thought that inclusion of a physician crew member was important for exploration missions, including the “Mars forward” NEA mission. Although this was the conclusion of the group, it was noted that the issue of inclusion of a physician astronaut would need to be vetted by the Space Medicine Division, the Astronaut Office, and other groups within NASA.

Among the drivers for inclusion of a physician astronaut were the inability to return to Earth for definitive medical care, the possibility of communication delay or blackout periods, and the relatively intangible value of the clinical acumen of a trained, practice-current physician. Participants argued that a physician with extensive experience with patient care would be comfortable with off-nominal events and able to improvise, if needed. The participants agreed that including more than 1 physician CMO (assuming a crew size of 3) would not be a good use of resources; however, they believed that all crew members should be familiar with performing expected medical procedures and should know the location of supplies and equipment.

The majority of medical events encountered during an exploration mission are expected to be routine, ambulatory, primary-care issues. Only a small percentage (estimated by participants to be less than 10%) would require advanced medical capabilities. It was also noted that very complex medical conditions would be rare occurrences and might have a lower likelihood of successful resolution.

The participants thought it would be more important to select an individual with the right experience and breadth of training than to select for a particular medical specialty; however, it was the opinion of the group that the ideal physician CMO would be a true general practitioner who has performed surgical procedures in the past and who can follow technical instructions well (through remote guidance or just-in-time training). It was noted that in other remote environments, most surgical and trauma conditions are handled by a non-surgeon. Participants stated that several of these groups use primary-care physicians who have been cross-trained in psychiatry. This additional training in behavioral health was thought to be extremely important and was emphasized several times throughout these discussions.

To accommodate a physician CMO, shifts in the current medical training of CMOs may be required. The group stressed that a physician CMO would need to be practice-current and should be given specific additional training on the in-flight diagnosis and treatment of conditions that are most likely to occur. During flight, the background of the CMO will dictate the skills that will need to be supplemented with virtual assistance. For example, if the CMO were a skilled surgeon, surgical procedures might not need to be assisted virtually, but primary-care assistance would need to be provided in a virtual manner. On the other hand, if a primary-care physician were selected as a CMO, then technical and procedural assistance would need to be provided virtually.

Workshop participants were queried about training programs currently used by remote-medicine organizations. Objective Structured Clinical Exams were discussed; these exams are used to assess the clinical and technical skills of physicians and could be used to assess a CMO's ability to diagnose and treat conditions on the medical condition list. Some remote-medicine organizations used pre-deployment checklists of skills needed in the remote environment. Such checklists could be adapted to use in training for exploration missions.

Patient Area in Spacecraft

Workshop participants were given a tour of NASA's Habitat Demonstration Unit and were asked to provide recommendations for improvements in the layout of the patient area.

Throughout discussions regarding the spacecraft patient area, workshop participants stressed that medical monitoring should be made as simple as possible. The spacecraft patient area should accommodate monitoring of an ill or injured crew member with little involvement by the CMO or deputy CMO. This is especially true in the case of the proposed 3-crew member NEA mission.

For telemedicine operations, the participants agreed that at least 1 camera, located in a position to allow the remote consultant to see both the patient and the examiner, would be needed. Some recommended the use of multiple cameras to ensure that the entire patient area is visible remotely. Participants thought that the primary camera(s) in the patient area should be fixed, which would prevent the view from being lost if a camera was accidently bumped. In addition to the camera(s) covering the patient area, the group thought that a second hand-held or hands-free camera would be needed for a close-up view of the patient.

The workshop participants agreed that multiple monitors (or a large monitor with split-screen capability) would be required for the patient area, to allow multiple images to be viewed simultaneously. It was noted that, for telemedicine consultations, the location of the patient area camera in relation to the monitor is very important. The camera should be located close to the monitor to provide the examiner and/or patient a feeling of connection with the remote consultant on Earth.

Participants thought that the patient monitor should be movable (as on a tablet or a heads-up display), rather than hard-wired. They noted that a completely wireless patient monitor may not be possible because of spacecraft bandwidth constraints and hardware limitations, and that a wired system capable of transmitting the data wirelessly to other displays would be adequate. As the ambient noise level within the spacecraft may vary, participants thought that the patient monitor should provide both auditory and visual cues if a parameter is out of range.

The capability to have the telemedicine equipment in the spacecraft patient area automatically activate in the case of an off-nominal medical event was discussed, but there was no consensus among the participants as to how this should be done. Some thought that audio and video monitoring of the spacecraft patient area should be continuous, whereas others stated that the monitoring equipment could be triggered via a button or via the activation of medical hardware.

The group determined that a patient table would not be necessary for a microgravity NEA mission; however, the ability to strap a patient to a wall or the floor would be required. It was recommended that foot restraints, handholds, rails, and/or Velcro points be incorporated into the design of the patient area.

Training

Workshop participants referenced documented literature on standard practice for telemedicine and familiarization training. According to the participants, most of the familiarization training in their organizations is done through online modules. They thought that a half-day overview course for crew members and consultants would be adequate for instruction in the use of telemedicine hardware.

It was recommended that the Flight Medicine Clinic use the telemedicine hardware that would be available during an exploration mission and practice time-delayed, ground-based cases with consultants. The importance of understanding and using the proper remote guidance terminology was stressed.

With respect to maintenance of proficiency in medical skills during flight, participants agreed that in-flight refresher training would be needed and that medical simulations should be utilized in training for off-nominal medical events.

Electronic Medical Records

External workshop participants identified the fact that electronic medical record (EMR) systems do not integrate longitudinally very well (for example, from ambulatory care to hospital care to long-term care) as one of the major challenges or limitations of the systems. The lack of interoperability of EMR systems is an existing gap that will need to be addressed. For a telemedicine consultation, the ability to send a longitudinal view of a crew member's history to external consultants will be necessary. Participants thought that the Veterans Health Information Systems and Technology Architecture (VistA), used

throughout the United States Department of Veterans Affairs medical system, is the most interoperable EMR system currently used in the United States.

An additional issue that was identified with regard to the EMR system is the fact that physician astronauts presently do not have access to the system, either on the ground or on the International Space Station. The external workshop participants thought that access to an onboard EMR system, which would contain crew members' medical history, should be available on board to crew members responsible for providing medical care during nominal or contingency operations.

Intelligent Clinical Care Systems

The integration of EMR systems with telemedicine hardware was identified as a key area for further development. Additional technologies are currently needed to facilitate interaction between the EMR system and telemedicine hardware, as the EMR systems available now do not allow for the storage of multimedia (such as images, audio, and video).

Several participants expressed the desire to have the EMR system integrated with other relevant databases (environmental information, for example). The integration of these systems would allow medical condition occurrences to be trended with environmental data.

Consultation Protocols

External workshop participants were not aware of any specific communication or consultation protocols for routine and emergency medical support, but they thought it would be necessary to develop best-practice guidelines for each anticipated clinical scenario. Best-practice guidelines will, for example, provide crew members with information about the appropriate images to capture and the appropriate time to capture them during a telemedicine consultation. It was recommended that the developed guidelines be tested with a group of providers to ensure that there is general agreement among the providers.

Prophylactic Surgical Procedures

Participants were asked which prophylactic surgical procedures should be considered for crew members on a 13-month NEA mission. The following procedures were discussed: appendectomy, cholecystectomy, tubal ligation (in pre-menopausal women), and oophorectomy (for ovarian cancer prevention in post-menopausal women); however, the group as a whole recommended that further research be conducted to determine what prophylactic surgical procedures remote medical care organizations recommend or require. It was noted that the procedural risks, complications, and ethical implications also need to be carefully considered before any prophylactic surgical procedure requirements are developed for a NEA mission.

Data Prioritization

With respect to the prioritization of data during a medical event, workshop participants thought that video from telemedicine consultations should be given priority over other medical data when bandwidth is

limited. Two of the participants stated that in their organization, video gets a bandwidth of 512 kilobits per second at all costs and that all other data are either downgraded or stopped to keep the integrity of the video. Participants thought that video from a real-time consultation provides the remote consultant with visual cues that can be more useful than the actual medical data (such as electrocardiogram results). They noted that video is essential for behavioral health and difficult medical case consultations, and is useful even with significant communication time delays (24 seconds, for example). If bandwidth is expected to be extremely limited, workshop participants recommended taking a store-and-forward hybrid approach to telemedicine consultations, sending medical data and high-definition video ahead of time and performing the real-time consultation with lower-resolution video.

Participants understood that the medical system will not have bandwidth priority during the day-to-day operations on a NEA mission, but expressed the opinion that the medical system should have priority in the case of a medical event that requires emergent consultation. A device that can automatically switch the bandwidth data priority if the situation warrants, would be desired.

To better understand the bandwidth requirements for telemedicine operations on a NEA mission, workshop participants recommended reviewing the bandwidth utilized for medical and behavioral health telemedicine consultations in space flight analog environments.

Workshop Attendees

Workshop Participants, External

Mary Ann Hopkins – New York University School of Medicine / Doctors Without Borders
Scott Simmons – University of Miami
Scott Dulchavsky – Henry Ford Hospital
Bernard Harris – Vesalius Ventures
Alexander Vo – University of Texas Medical Branch (UTMB)
Juan Carlos Diaz – Pan American World Health Organization
Rob Williams – Ontario Telemedicine Network
Rob Gerhardt – U.S. Army Institute of Surgical Research

Workshop Participants, Internal

Yael Barr – UTMB
Kristina Barsten – Enterprise Advisory Services, Inc.
Peter Bauer – NASA Johnson Space Center (JSC)
David Baumann – NASA JSC
Vicky Byrne – NASA JSC
Jonathan Clark – Baylor College of Medicine / National Space Biomedical Research Institute
Charles Doarn – NASA Headquarters
Kathleen Garcia – Wyle
DeVon Griffin – NASA Glenn Research Center
Douglas Hamilton – Wyle
Kathy Johnson-Throop – NASA JSC
Smith Johnston – NASA JSC
Eric Kerstman – UTMB
Michael Krihak – NASA Ames Research Center (ARC)
Jennifer Law – UTMB
Kjell Lindgren – NASA JSC
Shannon Melton – Wyle
Christian Otto – Universities Space Research Association (USRA)
Camille Shea – USRA
William Tarver – NASA JSC
Sharmila Watkins – UTMB
Robert Whalen – NASA ARC
Jimmy Wu – Wyle

Workshop Support

Marilyn Sylvester – Wyle
Holly Williams – JES Tech

Agenda

Thursday, January 20, 2011

Time	Topic
8:00	*Registration*
8:10	**Welcome and Introductions** – *Dr. Sharmi Watkins*
8:20	**Workshop Overview and Goals** – *Dr. Sharmi Watkins*
8:30	**Overview of the Medical Operations Concept** – *Dr. Christian Otto*
9:30	**NASA and Telemedicine – An Evolution** – *Mr. Charles Doarn*
10:15	*Break*
10:30	**Remote Medicine Presentation** – *Dr. Alexander Vo*
11:00	**Remote Medicine Presentation** – *Mr. Scott Simmons*
11:30	**Remote Medicine Presentation** – *Mr. Juan Carlos Diaz*
12:00	*Lunch*
12:30	**Remote Medicine Presentation** – *Dr. Scott Dulchavsky*
1:00	**Remote Medicine Presentation** – *Dr. Rob Williams*
1:30	**Remote Medicine Presentation** – *Dr. Mary Ann Hopkins*
2:00	**Remote Medicine Presentation** – *Dr. Robert Gerhardt*
2:30	*Break*
2:45	**Telemedicine Case Studies** – *Dr. Jennifer Law*
5:00	*Adjourn*

Friday, January 21, 2011

Time	Topic
7:45	**Depart for Tour of Johnson Space Center – Buildings 9 and 30**
11:00	**Telemedicine Operational Concept: Comments Received** – *Ms. Kristina Barsten*
12:00	*Lunch*
12:30	**Directed Questions and Discussion**
2:30	*Break*
2:45	**Directed Questions and Discussion**
4:45	**Closing Comments**
5:00	*Adjourn*

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