

Cervical Spine Intervertebral Disc Herniation on board the International Space Station: Diagnosis, Treatment and Operational Mission Impact

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Panel Overview- Rick Scheuring

INTRODUCTION: The authors describe the diagnosis, acute treatment, and rehabilitation of a mission impacting musculoskeletal medical condition in an astronaut during long-duration space flight on board the International Space Station. **BACKGROUND:** Rarely does a medical condition present in astronauts during the on-orbit phase of a space mission that has direct impact on crew health and mission objectives. During the record setting, long-duration mission of a U.S. astronaut, the team of NASA flight surgeons, astronaut strength conditions and rehabilitation experts along with outside consultants in neuro- and orthopedic spine surgery were presented with a case of acute onset cervical spine pain. The condition progressed in severity ultimately forcing the mission planners to reschedule an extravehicular activity (EVA), or spacewalk, modify the existing on orbit exercise prescription, and consider factors for an unscheduled return to Earth. There is no precedent for this type of musculoskeletal condition occurring in space prior to this case. The medical team had to develop an rehabilitation program on the ISS and consider alternatives to mission continuation in the event the individual did not respond to treatment. **CASE PRESENTATION:** A previously healthy US astronaut developed acute cervical spine pain during his 12-month mission on board the International Space Station (ISS). Details regarding the medical condition and treatment, rehabilitation plan, associated operational impacts, and spinal pathophysiology will be presented during this panel. **DISCUSSION:** Human space flight poses unique challenges to the diagnosis, treatment and monitoring of medical conditions. Flight surgeons rely on telemedicine for patient care, and the microgravity environment presents unknown physiological and anatomical changes to the human spine. A musculoskeletal rehabilitation treatment program was required to treat this medical condition, which prior to this mission, had never existed. Lastly, impacts to the mission objectives need to be considered.

Diagnosis and Treatment- Rick Scheuring

INTRODUCTION: A previously healthy, 55-year-old male astronaut, with prior military and spaceflight experience, developed non-specific cervical spine pain approximately four months into his 12-month mission. **BACKGROUND:** Non-specific, limited musculoskeletal spine pain in astronauts in microgravity have been acknowledged during the six decades of human spaceflight. More recently, spinal changes have been studied and documented with pre- and post-flight imaging and on orbit stature measurements. Clinically, flight surgeons routinely observe mild, transient low back pain upon initial introduction of microgravity exposure in their crew members. However, standard screening assessments of spine integrity have not been routinely performed unless clinically indicated. Therefore, flight surgeons have had little insight

to what underlying spine pathology may be brought into spaceflight. **CASE PRESENTATION:** The exact mechanism of injury in this astronaut was not clearly evident from his history. Despite conservative management, he subsequently developed an acute left sided C7 cervical radiculopathy 3-4 weeks after initial presentation of pain. His symptoms primarily consisted of radiating arm pain and numbness in a C7 distribution in addition to left sided triceps weakness noted during exercise. He did not have any changes in fine motor skills or evidence of myelopathy, although gait analysis was obviously limited. **DISCUSSION:** Despite the relatively permanent spine traction state in microgravity and conservative treatment measures, the individual developed unilateral C7 sensori-motor radiculopathy attributed to a C6-7 herniated nucleus pulposus. The crew member was removed from a scheduled EVA and began a treatment program on ISS to relieve his symptoms and return him to exercise. Upon consultation with experts in neurosurgery and orthopedic spine surgery assisted in the diagnosis, given the constraints of telemedicine during space flight, and guided conservative therapeutics regimen. Serial ultrasound imaging was conducted to evaluate the suspected levels in the cervical spine and aid in the differential diagnosis. The on-orbit exercise prescription was modified in consultation with the astronaut strength, conditioning, and rehabilitation (ASCR) team. Approximately 8-10 weeks after his initial presentation his symptoms improved to the point he was able to resume his full exercise routine and ultimately completed his entire mission duration.

Operational Mission Impacts- Rainer Effenhauser

INTRODUCTION: On-Orbit medical Issues have the potential to significantly impact spaceflight mission timelines and operations. This panel segment will discuss the Operational Impacts of a medical issue that occurred during spaceflight and the associated challenges and impacts to subsequent mission schedule and operations. These include things such as performing extravehicular activity (EVA, or spacewalks), exercise, and potential impacts to mission completion and subsequent landing operations. Familiarization with how daily crew activities developed by NASA Mission Operations planners are implemented and used by the astronauts during spaceflight will also be discussed. **CASE PRESENTATION:** A 55 y/o male American astronaut developed cervical spine pain during his year-long mission on board the International Space Station (ISS). Symptom severity and confounding symptom presentation, i.e.. paresthesia in the upper extremity, which may present during an EVA and represent acute decompression illness, prompted the mission medical team, mission managers and planners, along with medical specialists and the individual crew member to reconsider several mission objectives. **DISCUSSION:** At the end of this panel presentations, participants will be familiar with what a spaceflight mission schedule looks like, and how both minor and major medical issues have the potential to significantly impact mission timelines, operations, activities such as EVA, exercise, mission completion, and landing planning/operations.

On-orbit musculoskeletal rehabilitation- Danielle Anderson

INTRODUCTION: Cervical radiculopathy is a common condition seen within the civilian population. The incidence and prevalence are higher in operational environments with frequent exposures to g-forces and microgravity. The implications for mismanagement can be extreme and lead to severe disability and increased healthcare cost and utilization. In an environment that is 250 miles above earth, these implications are even more severe with operational impacts, minimal ability to medically evacuate and treat an individual, and an obligation to maintain the full health and safety of a crew member. Due to these demanding requirements and limited capabilities, innovative rehabilitation strategies are necessary to treat and mitigate long term impacts of the condition. **BACKGROUND:** ~10-20% of cervical radiculopathy cases require surgical intervention, leading to the majority of cases being managed conservatively by physicians and physical therapists. There is plenty of evidence to support conservative treatment through appropriate medication management, manual physical therapy intervention, and individually tailored exercises targeted to resolve symptoms of radicular pain, numbness/tingling, and cervical pain and dysfunction. Although well established in 1-g, this evidenced based approach to treat cervical radiculopathy is unknown in the microgravity environment. The evidence-based principles of physical therapy evaluation and treatment of cervical radiculopathy will be discussed and applied to a real case of an astronaut on-board the International Space Station. The rehabilitation program consisting of individually tailored cervical and thoracic mobility exercises and manually applied cervical traction and cervical rotation, performed by a seasoned Astronaut physician in microgravity, will all be discussed. **CONCLUSION:** Relying on advanced clinical decision making, evidenced based principles of effective management in 1-g, and crew member ingenuity, effective treatment can be applied to fully resolve, maintain fitness, and mitigate long-term disability in microgravity, as demonstrated by a case of a 1-year long mission crew member on-board the International Space Station. Although the management of this case demonstrates a unique strategy to treatment, these cases are common in microgravity and will require imaging surveillance and pathological and physical characteristics assessment, to effectively prevent and treat future spine conditions in microgravity.

Spinal Pathophysiology- Mel Helgeson & Paul Holman

INTRODUCTION: The spinal pathophysiology of long-duration space flight is not fully understood. We present a case discussion of spinal pathology in relation to a recent astronaut who developed cervical radiculopathy during flight. **BACKGROUND:** Throughout the history of human spaceflight, researchers have sought to better understand the significant impact on the musculoskeletal system and the spine. Several case reports exist within the literature describing the acute impact on spinal morphology and it is widely accepted that the spine elongates up to six centimeters when humans are exposed to the microgravity environment. While the spine anatomy changes, decreasing the normal sagittal alignment of kyphosis/lordosis, the spine also undergoes traction during flight. This traction and loss of loading

across the intervertebral disk undoubtedly leads to changes within the microarchitecture of the disk space. There has been an increase in disk herniations, with up to 10% of US astronauts sustaining disk herniations post flight. There have not been any reports of disk herniations developing during space flight or any episodes of cervical/lumbar radiculopathy. **CASE PRESENTATION:** Without the ability to perform standard cervical spine imaging (MRI) on board the International Space Station, the assumption was this individual's signs and symptoms represented an acute disk herniation. Knowing traction occurs within the microgravity environment caused concern among the medical team members, and led to a conservative approach to activities, cancelling his scheduled EVA. The team could also not rule out spinal cord compression without available imaging. Proceeding cautiously with conservative management, his symptoms improved over the next 3 months, consistent with the natural history of cervical radiculopathy. His post-flight MRI obtained 24 hours after landing, eight months after the development of symptoms, revealed significant degenerative changes at the suspected level. **DISCUSSION:** The management of acute cervical radiculopathy is well accepted to be conservative initially in the absence of myelopathy. Conservative treatment was appropriate in this case, but the medical team was concerned about the possibility of spinal cord compression and the uniqueness of symptoms within a traction, microgravity environment. The pathophysiology of disk herniations within this environment needs to be better understood as we seek more frequent and longer duration flights.