Decompression Sickness

Introduction

Decompression Sickness (DCS) occurs when the ambient pressure decreases, leading to formation of gas bubbles in the tissues and/or blood from gases (mainly nitrogen) that, under atmospheric pressure, are otherwise in solution. DCS can occur during space flight when a crewmember is exposed to the lower pressure found in the Extravehicular Mobility Unit (EMU) used for Extravehicular Activities (EVA), or if the pressure inside the space craft decreases either intentionally (for example, in preparation for an EVA) or unintentionally (for example, due to collision with a meteorite). The risk of DCS increases as the ambient pressure decreases, with longer time of exposure to the lower pressure, and if physical exersion occurs during the exposure. The risk decreases with pre-oxygenation, particularly when combined with exercise.[1] DCS may manifest with a variety of signs and symptoms, including joint and limb pain, paresthesias, numbness, dizziness, fatigue, and many others.[1] Basic treatment, including limited hyperbaric oxygen therapy, is available on orbit.[1]

Clinical Priority and Clinical Priority Rationale by Design Reference Mission

One of the inherent properties of space flight is a limitation in available mass, power, and volume within the space craft. These limitations mandate prioritization of what medical equipment and consumables are manifested for the flight, and which medical conditions would be addressed. Therefore, clinical priorities have been assigned to describe which medical conditions will be allocated resources for diagnosis and treatment. “Shall” conditions are those for which diagnostic and treatment capability must be provided, due to a high likelihood of their occurrence and severe consequence if the condition were to occur and no treatment was available. “Should” conditions are those for which diagnostic and treatment capability should be provided if mass/power/volume limitations allow. Conditions were designated as “Not Addressed” if no specific diagnostic and/or treatment capability are expected to be manifested, either due to a very low likelihood of occurrence or other limitations (for example, in medical training, hardware, or consumables) that would preclude treatment. Design Reference Missions (DRMs) are proposed future missions designated by a set of assumptions that encompass parameters such as destination,

<table>
<thead>
<tr>
<th>Design Reference Mission</th>
<th>Clinical Priority</th>
<th>Clinical Priority Rationale</th>
</tr>
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<tbody>
<tr>
<td>Lunar sortie mission</td>
<td>Shall</td>
<td>The lunar sortie mission scenario involves several venues where pressure is expected to nominally change, including transfers between a pressurized habitat, a pressurized rover, and a pressurized EVA suit. Off-nominal contingencies may involve unintended pressure changes in any of the above, with development of decompression sickness. Therefore, treatment capability shall be manifested.</td>
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<tr>
<td>Assumptions:</td>
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<tr>
<td>4 crewmembers (3 males, 1 female)</td>
<td></td>
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<tr>
<td>14 days total</td>
<td></td>
<td></td>
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<tr>
<td>4 EVAs/crewmember</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of Care 3</td>
<td></td>
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<tr>
<td>Lunar outpost mission</td>
<td>Shall</td>
<td>The lunar outpost mission scenario involves several venues where pressure is expected to nominally change, including transfers between a pressurized habitat, a pressurized rover, and a pressurized EVA suit. Off-nominal contingencies may involve unintended pressure changes in any of the above, with development of decompression sickness. Therefore, treatment capability shall be manifested.</td>
</tr>
<tr>
<td>Assumptions:</td>
<td></td>
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<tr>
<td>4 crewmembers (3 males, 1 female)</td>
<td></td>
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<tr>
<td>180 days total</td>
<td></td>
<td></td>
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<tr>
<td>90 EVAs/crewmember</td>
<td></td>
<td></td>
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<tr>
<td>Level of Care 4</td>
<td></td>
<td></td>
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<tr>
<td>Near-Earth Asteroid (NEA) mission</td>
<td>Shall</td>
<td>The NEA transit mission is not expected to involve scheduled EVAs, but contingency EVAs may need to be performed during the months-long transit. NEA proximity operations will involve venues where the ambient pressure is expected to nominally decrease (EVAs). In addition, off-nominal contingencies may involve unintended pressure changes in the space craft (for example: compromise of vehicle integrity due to collision with debris). Therefore, treatment capability shall be manifested.</td>
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<tr>
<td>Assumptions:</td>
<td></td>
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<tr>
<td>3 crewmembers (2 males, 1 female)</td>
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<tr>
<td>395 days total</td>
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<tr>
<td>30 EVAs/crewmember</td>
<td></td>
<td></td>
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<tr>
<td>Level of Care 5</td>
<td></td>
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Initial Treatment Steps During Space Flight
A link is provided to a prior version of the International Space Station (ISS) Medical Checklist, which outlines the initial diagnostic and treatment steps recommended during space flight for various conditions which may be encountered onboard the ISS. Further diagnostic and treatment procedures beyond the initial steps outlined in the Medical Checklist are then recommended by the ground-based Flight Surgeon, depending on the clinical scenario. Please note that this version does not represent current diagnostic or treatment capabilities available on the ISS. While more recent versions of this document are not accessible to the general public, the provided version of the checklist can still provide a general sense of how medical conditions are handled in the space flight environment. Medical Checklists will be developed for exploration missions at a later point in time.

Please note this file is over 20 megabytes (MB) in size, and may take a few minutes to fully download.

ISS Medical Checklist (http://www.nasa.gov/centers/johnson/pdf/163533main_ISS_Med_CL.pdf)

Capabilities Needed for Diagnosis

The following is a hypothetical list of capabilities that would be helpful in diagnosis. It does not necessarily represent the current capabilities available onboard current spacecraft or on the ISS, and may include capabilities that are not yet feasible in the space flight environment.

- Vital signs measurement capability (blood pressure, pulse, respiratory rate, temperature, pulse oximetry, as required per the patient's clinical state)
- Auscultation device (such as a stethoscope)
- Cardiac [Electrocardiograph (ECG)] monitor
- Imaging (such as ultrasound)
- Otoscope/Ophthalmoscope
- Blood analysis [Complete Blood Count (CBC), electrolytes]

Capabilities Needed for Treatment

The following is a hypothetical list of capabilities that would be helpful in treatment. It does not necessarily represent the current capabilities available onboard current spacecraft or on the ISS, and may include capabilities that are not yet feasible in the space flight environment.

- Hyperbaric treatment device
- Supplemental oxygen
- Intravenous (IV) start and administration kit (rapid access may be needed)
- IV pump or pressure infuser
- Intravascular volume replacement (such as IV fluids)
- Sharps container
- Non-sterile gloves
- Skin cleanser [such as alcohol/Benzalkonium antiseptic (BZK)/iodine]
- Decongestants
- Analgesics (non narcotic, narcotic, oral, injectable)
- Potable water
- Intubation kit [for cardiopulmonary DCS, Acute Gas Embolism (AGE), or lung barotrauma]
- Ventilator (for cardiopulmonary DCS, AGE, or lung barotrauma)

Associated Gap Reports

The NASA Human Research Program (HRP) identifies gaps in knowledge about the health risks associated with human space travel and the ability to mitigate such risks. The overall objective is to identify gaps critical to human space missions and close them through research and development. The gap reports that are applicable to this medical condition are listed below. A link to all of the HRP gaps can be found here [http://humanresearchroadmap.nasa.gov/Gaps/](http://humanresearchroadmap.nasa.gov/Gaps/).

2.01 - We do not know the quantified health and mission outcomes due to medical events during exploration missions.
2.02 - We do not know how the inclusion of a physician crew medical officer quantitatively impacts clinical outcomes during exploration missions.
3.01 - We do not know the optimal training methods for in-flight medical conditions identified on the Exploration Medical Condition List taking into account the crew medical officer’s clinical background. (Closed)
3.03 - We do not know which emerging technologies are suitable for in-flight screening, diagnosis, and treatment during exploration missions.
4.01 - We do not have the capability to provide a guided medical procedure system that integrates with the medical system during exploration missions.
4.04 - We do not have the capability to deliver supplemental oxygen to crew members while minimizing local and cabin oxygen build-up during exploration missions.
4.05 - We do not have the capability to measure laboratory analytes in a minimally invasive manner during exploration missions.
4.12 - We do not have the capability to generate and utilize sterile intravenous fluid from potable water during exploration missions.
4.14 - We do not have the capability to track medical inventory in a manner that integrates securely with the medical system during exploration missions.
4.15 - Lack of medication usage tracking system that includes automatic time stamping and crew identification
4.17 - We do not have the capability to package medications to preserve stability and shelf-life during exploration missions.
4.19 - We do not have the capability to monitor physiological parameters in a minimally invasive manner during exploration missions.
4.23 - We do not have the capability to auscultate, transmit, and record body sounds during exploration missions.
4.24 - Lack of knowledge regarding the treatment of conditions on the Space Medicine Exploration Medical Condition List in remote, resource poor environments (Closed)
5.01 - We do not have the capability to comprehensively manage medical data during exploration missions.

Other Pertinent Documents

List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AGE</td>
<td>Acute Gas Embolism</td>
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https://humanresearchwiki.jsc.nasa.gov/index.php?title=Decompression_Sickness
References


Last Update

This topic was last updated on 8/12/2014 (Version 2).


Category: Medical Conditions