Nephrolithiasis

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Introduction

The formation and passage of kidney stones (nephrolithiasis), if occurring during space flight, have the potential to impact crewmember health and mission success. Astronauts may be at an increased risk of stone development during space flight due to the physiological alterations caused by microgravity and by other aspects of living in space (for example: relative dehydration, altered bone metabolism leading to hypercalciuria, and changes in urinary composition that favor stone formation).[1][2]

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, length of mission, number of crewmembers, number of Extravehicular Activities (EVAs), and anticipated level of care. The clinical priorities for all medical conditions on the Exploration Medical Condition List (EMCL) can be found here (https://humanresearchwiki.jsc.nasa.gov/index.php?title=Category:All_DRM). The EMCL document may be accessed here (https://humanresearchwiki.jsc.nasa.gov/images/6/62/EMCL_RevC_2013.pdf).

Design Reference Mission	Clinical Priority	Clinical Priority Rationale
Lunar sortie mission Assumptions: ▪ 4 crewmembers (3 males, 1 female) ▪ 14 days total ▪ 4 EVAs/ crewmember ▪ Level of Care 3	Shall	An untreated kidney stone on a lunar sortie mission can result in severe pain, and may lead to infection, sepsis, and a need for evacuation. Crewmembers may be at an increased risk of stone development due to the biochemical alterations caused by microgravity (for example: hypercalciuria). Treatment shall thus be provided.
Lunar outpost mission Assumptions: ▪ 4 crewmembers (3 males, 1 female) ▪ 180 days total ▪ 90 EVAs/ crewmember ▪ Level of Care 4	Shall	An untreated kidney stone on a lunar outpost mission can result in severe pain, and may lead to infection, sepsis, and the need for evacuation. Crewmembers may be at an increased risk of stone development due to the biochemical alterations caused by microgravity (for example: hypercalciuria). Treatment shall thus be provided.
Near-Earth Asteroid (NEA) mission Assumptions: ▪ 3 crewmembers (2 males, 1 female) ▪ 395 days total ▪ 30 EVAs/ crewmember ▪ Level of Care 5	Shall	An untreated kidney stone on the long-duration Near Earth Asteroid mission can result in severe pain, and may lead to infection and potentially sepsis. Crewmembers may be at an increased risk of stone development due to the biochemical alterations caused by microgravity (hypercalciuria). Treatment shall thus be provided.

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, as required per the patient's clinical state)
- Imaging modality [such as ultrasound, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Intravenous Pyelography (IVP), or urography]
- Auscultation device (such as a stethoscope)
- Urine analysis
- Microscope

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.

- Crew medical restraint system
- Analgesics (non narcotic, narcotic, oral, injectable)
- Antiemetics (oral, injectable)
- Medication delivery device (such as Carpuject Injector)
- Skin cleanser [such as alcohol/Benzalkonium antiseptic (BZK) /iodine]
- Bandaging
- Non-sterile gloves
- Sharps container
- Tape
- Intravascular volume replacement (such as IV fluids)
- IV start and administration kit
- IV pump or pressure infuser
- Lithotripsy
- Surgical treatment

Associated Gap Reports

1.01 - We do not know which emerging technologies are suitable for preflight medical screening for exploration missions.
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.
4.02 - We do not have the capability to provide non-invasive medical imaging 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.
4.13 - We have limited capability to screen for, diagnose, and treat renal stones 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.
4.24 - 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

B	
BZK	Benzalkonium Antiseptic
C	
CT	Computed Tomography
D	
DRM	Design Reference Mission
E	
EMCL	Exploration Medical Condition List
EVA	Extravehicular Activity
I	
ISS	International Space Station
IV	Intravenous
IVP	Intravenous Pyelography

M	
MB	Megabyte
MRI	Magnetic Resonance Imaging
N	
NEA	Near Earth Asteroid

References

1. Whitson PA, Pietrzyk RA, Morukov BV, Sams CF. The risk of renal stone formation during and after long duration space flight. Nephron. 2001 Nov;89(3):264-70.
2. Pietrzyk RA, Jones JA, Sams CF, Whitson PA. Renal stone formation among astronauts. Aviat Space Environ Med 2007 Apr;78(4 Suppl):A9-13.

Last Update

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