Operational Impact of an Onboard Pharmacy: Mission Impact and Risk Considerations

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Goals

- Discuss the operational impacts of the onboard pharmacy
- Discuss risks associated with the inability to supply a safe, robust, and comprehensive formulary for long-duration spaceflight outside of low-Earth orbit (LEO)
- Discuss implications of these risks
- Discuss potential mitigation strategies to address this risk

Outline

- Introduction
- Concerns/Risks
- Implications
- Potential Solutions

Introduction

- Pharmaceutical intervention is essential component of risk management for astronaut healthcare during exploration spaceflight
- Historically, medication use has not been comprehensively monitored (largely due to crew time constraints)
- Currently, certain medications can be used without prior consultation with a flight surgeon (e.g. OTCs for headache or congestion)
- Such use may be reported during weekly Private Medical Conferences (PMCs), but there is currently no requirement to do so
- However, due to delayed reporting, information such as indication, dose, timing, or side effects may not be reported or recorded

Introduction

- Medication use reporting has improved over time (as discussed by previous presenter)

- Common complaints: headache, congestion, sleep disturbance, space motion sickness

Introduction

- With stricter reporting, the significance of an on-board pharmacy becomes clear
- NASA's Human Research Roadmap (HRR) identifies medication use as a potential countermeasure for prevention or management of several conditions
  - Examples include:
    - Potassium citrate for nephrolithiasis prophylaxis
    - Pain medication for EVA-induced pain or injuries
    - Antidepressants or antipsychotics for adverse cognitive or behavioral conditions and psychiatric disorders
    - Bisphosphonates for bone fracture due to spaceflight-induced changes to bone
- In analysis of medical capabilities needed for a Mars transit mission, NASA’s Exploration Medical Capability (ExMC) element preliminarily identified onboard pharmacy as the largest single component of a complete medical system (>25% of all medical interventions)

Concerns/Risks

- Anecdotal evidence that medications may be less efficacious in spaceflight
  - Space Shuttle – Putcha (1999)
    - 13 different medications “not effective” or “mildly effective”
  - Space Shuttle/ISS – Barger (2014)
    - Sleep medication – 17-19% of cases required second dose
- Medication stability
  - 87% of medications flown on ISS have shelf lives <24 months
  - Many may be repackaged to save weight/volume, especially for exploration missions
  - Radiation can play a role in degradation of API (active pharmaceutical ingredient)
  - Significant limitation for exploration-class missions

Concerns/Risks

- PK/PD may be altered
  - Pharmacokinetics (body effects on medications)
  - Pharmacodynamics (medication effects on body)
- Altered microbial growth and antimicrobial susceptibility
- Inability to evacuate to Earth quickly

Implications

- Bottom Line:
  - These concerns/risks may lead to a medication being unavailable when needed without the ability to resupply or evacuate the patient
  - Without a safe and comprehensive on-board pharmacy, may not be able to fully address certain medical issues in an astronaut during an exploration-class mission
- If unable to fully treat medical condition:
  - Potential performance decrements that could impact successful completion of science and/or mission
  - Additional time/resources in space and on the ground devoted to a problem that may have been rectified with appropriate medication
  - Use of sub-optimal medication to manage condition may mean that this medication is unavailable to treat another better-suited issue later in the mission

Potential Solutions

- Goal: Supply a safe, robust, and comprehensive pharmacy for long-duration spaceflight outside of LEO

- Standardized documentation or medication tracking to provide better physician awareness and allow for more accurate inventory management
- Better medical condition/risk prediction in order to appropriately weigh trades when optimizing the on-board exploration medical system
- Investigation/research into:
  - Stability and/or shelf-life extension
  - Ground-based radiation exposure
  - PK/PD


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Thank you

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