Fingernail Injuries & NASA's Integrated Medical Model

Laura Thompson, D.O.

With Dr. Eric Kerstman, UTMB and Doug Butler, Wyle Integrated Science and Engineering.

All research done during Aerospace Medicine Clerkship, 4 week rotation sponsored by Wyle Integrated Science and Engineering and NASA's Johnson Space Center.

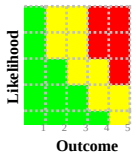
INTRODUCTION

•The goal of space medicine is to optimize both crew health and performance.
•Currently, expert opinion is primarily relied upon for decision-making regarding medical equipment and supplies flown in space.
•Evidence-based decisions are preferred due to mass and volume limitations and the expense of space flight.
•The Integrated Medical Model (IMM) is an attempt to move us in that direction!

What is IMM?

•Software based tool used to forecast risk of medical conditions in space flight.
•Utilizes evidence-based information as inputs to establish a defensible position for making decisions to optimize crew health and mission success.
•Multiple conditions are modeled at once.
•Best used when comparing the risk of two or more mission profiles, not as a tool for predicting absolute risk.
•If a "mission" is simulated 50-100,000 times with a given set of medical capabilities (risk mitigations), a estimation of the most probable outcomes can be generated.

Risk Matrix



Clinical Findings Forms

CliFFs - written for each medical condition modeled in the IMM.
•Incidence rate for the medical condition
•Patient population (comparison group)
•Treatment options (resources/risk mitigations)
•Clinical outcomes

CliFF for Fingernail Injuries

Mission information	Incidence (events/EVA)	Incidence (events/person-year)
Apollo (5), STS (3), ISS (2)	0.046	0.395

10 cases occurred during 216 EVAs by U.S. astronauts.
10 cases occurred during 27.85 person-years of space flight.

Tables of Treatments and Outcomes

	Clinical Phase I – Diagnosis & Initial Treatment		Clinical Phase II –On-going Treatment/ Convalescence		Clinical Phase III – Recovered/ Mission End State	
TREATMENT OPTIONS	**FI (%)**	**Duration (hrs)**	**FI (%)**	**Duration (hrs)**	**FI (%)**	**End state results**
ISS-based Treatment (best case scenario: 95-100%)	100%	0.25	10 - 24	72 - 336	0 – 9 %	N/A
ISS-based Treatment (worst case scenario: 0-5%)	100%	0.5	25 - 95	240 - 336	10 – 24%	N/A
Untreated Case	N/A	N/A	10 - 95	72 - 336	0 – 24%	N/A

Cases of Reported Nail Trauma While in Space

Space Transportation System (STS):

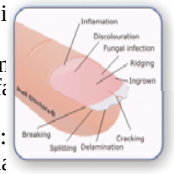
1. Some tender nails post-EVA 3, subungual bruising/bleeding
2. Damage/trauma to nailbeds from gloves during EVA, subungual bruising/bleeding
3. Nail tip trauma from EVA. Subungual bruising/bleeding. Unable to use dermabond.
4. Sore cuticles, subungual bruising x1
5. Fingertips bruised/dry, a lot of manual handling, subungual bruising/bleeding

International Space Station (ISS):

1. Mild-moderate crush injury to R index finger while on orbit. A small amount of subungual contusion remains and a new nail is growing in. Nail will slough in short order. (Extracted from postflight PEX)

Hand Complaints

Superficial abrasi
Contusions
Peripheral nerve impir
Generalized hand fa



▪Distribution:
Fingertips/na
Glove compress
Fatigue 8

Forces on Fingernails

The constant flexing of the fingers due to the "grasp and release" motion of the hands can result in mild trauma to the fingernails & the nails tend to pull away from the underlying finger.

In space, astronauts' work schedules may not provide them with the option of stopping work if this condition should occur.

Furthermore, the warm, moist environment inside an astronaut's glove is highly conducive to the growth of bacteria.

CONCLUSION

•Many potential injuries are now prevented with the use of available countermeasures and improved fitting of the suits.
•However, improvements can still be made in glove design to reduce fingertip loading and to improve gas flow around fingertips.
•An average of six months is needed for the injured nail to fully re-grow, therefore, prevention is key:
•Hand strengthening & ergonomics training
•Optimize arm length, elbow convolute, glove fit
•Improved moisture wicking comfort gloves
•Keep fingernails clipped as short as possible
•Utilize available countermeasures:
•Sally Hansens nail hardener, Dermabond, Tegaderm, Moleskin, Bandaids, tape, etc.