An Introduction to Aerospace Medicine at NASA

Ronak V. Shah, DO, MBA, MPH
Medical Director of Clinical Services
NASA Johnson Space Center

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The NY Minute

- NY/NJ native
- Internal medicine
- Aerospace medicine
- Research
- Operational support
- Medical Director
What is Aerospace Medicine?

• TRADITIONAL MEDICINE
  Abnormal physiology in a normal environment

• AEROSPACE MEDICINE
  Normal physiology in an abnormal environment
Hazards of Spaceflight

Space Environment

Spacecraft Environment

Spaceflight Mission
Space Radiation

- Three main sources
  - GCR **biggest threat to deep space missions**
  - Trapped Radiation
  - Solar particle events
- Exposure based on orbital altitude/inclination, duration, and solar activity
- Shielding from Earth’s atmosphere is roughly equivalent to 10 m of water
# Radiation Dose Ranges

<table>
<thead>
<tr>
<th>Activity</th>
<th>Typical Dose (rem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round-trip NY to London / Chest x-ray (1 film)</td>
<td>0.01</td>
</tr>
<tr>
<td>Natural background radiation per year</td>
<td>0.3</td>
</tr>
<tr>
<td>CT scan</td>
<td>3-10</td>
</tr>
<tr>
<td><strong>Typical mission dose on ISS</strong></td>
<td>10-15</td>
</tr>
<tr>
<td>Estimated dose for 3-yr Mars mission</td>
<td>100-150</td>
</tr>
<tr>
<td>Atomic bomb survivors</td>
<td>Up to 400</td>
</tr>
<tr>
<td>Human LD$_{50}$, no medical intervention</td>
<td>350-550</td>
</tr>
<tr>
<td>Human LD$_{50}$, with medical intervention</td>
<td>500-1000</td>
</tr>
</tbody>
</table>
ISS Radiation Shielding

Well Shielded
- Node 2 USOS Crew Quarters
- Service Module, aft of treadmill

Not Well Shielded
- Lab Window
- Cupola
- Airlocks
- Service Module, fore of treadmill (Russian crew quarters)
Quick Foray into Orbital Mechanics

- ISS doesn’t “escape gravity”
- Microgravity aboard the ISS a result of freefall
- The station is constantly falling ‘over the horizon’
Neurovestibular Physiology

- Sense of orientation
- Balance / posture
- Pursuit tracking / maintaining gaze
- Smooth movement

EYES
- Vision

INNER EARS
- Linear acceleration
- Angular acceleration

SPINAL / PERIPHERAL NERVOUS SYSTEM
- Proprioception (body position and movement)
Space Motion Sickness

Photo: NASA
Fluid Shifts During Spaceflight

Lujan and White (1995)
An Example of Fluid Shift

Shortly after reaching orbit:

- Leg volume decreases by ~1 L per leg
- Forehead tissue thickness increases by ~7% compared to preflight supine control
Bone Loss During Spaceflight

Post-flight changes in bone density compared to preflight
Potential Problems Secondary to Bone Loss

- Altered calcium metabolism
- Reduced emergency egress capability
- Kidney stones
- Fractures
**In-Flight Exercise Countermeasures**

2.5 hours of exercise scheduled daily

<table>
<thead>
<tr>
<th></th>
<th>T2 (Treadmill 2)</th>
<th>CEVIS (Cycle Ergometer with Vibration Isolation &amp; Stabilization)</th>
<th>ARED (Advanced Resistive Exercise Device)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neurovestibular</strong></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cardiovascular</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Musculoskeletal</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

T2 (Treadmill 2) provides cardiovascular and musculoskeletal benefits.

CEVIS (Cycle Ergometer with Vibration Isolation & Stabilization) offers all three benefits.

ARED (Advanced Resistive Exercise Device) is also beneficial for all three areas.
Launch Landing Ops
Launch and Landing of Russian Soyuz – Medical Support for US and Partner Astronauts

**Launch – Baikanour**
- USOS 1 Crew Surgeon, 1 Deputy Crew Surgeon, 1 Russian Based US Physician
- IP – 1 IP Surgeon

**Landing – Kazakhstan**
- USOS 1 Crew Surgeon, 1 Deputy Crew Surgeon, 1 Russian Based US physician
- IP – 1 IP Surgeon
- Direct Return Doctor
Launch and Landing of Russian Soyuz – Medical Support for US and Partner Astronauts

R+0 Route of Flight

- Goose Bay
- Bangor
- Reykjavik
- Prestwick
- Edinburgh
- Mildenhall
- Bodo
- Helsinki
- Astana
- Karaganda
- Kostanay
- China
Launch and Landing of Russian Soyuz – Medical Support for US and Partner Astronauts

• Launch - Capabilities
  • Trauma Kit
  • Launch specific supplement
  • Local facilities
  • Russia based US doctor for coordination

• Landing – Capabilities
  • Trauma Kit
  • Ultrasound, Vscan, fluid warmer, vein finder, iStat
  • Landing specific supplement
  • Local facilities
  • Russia based US doctor for coordination
Launch/Landing Medical Pack

April 2016
Trauma Pack
Emerg Meds Pocket

- EpiPen 1
- Diphenhydramine 50mg IM/IV 2
- Prednisone 20mg PO 3
- Nitroglycerin Sublingual Tablets 25
- Albuterol HFA 1
- Syringe 3cc 2
- Needle 20-22G 1.5” 2
- Epinephrine 1:10,000 injectable 3
Trauma Pack
I.V. Pouch

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV Setups (Smartsite Infusion Set)</td>
<td>2</td>
</tr>
<tr>
<td>IV pressure Infuser</td>
<td>1</td>
</tr>
<tr>
<td>NS 0.9% 1 Liter</td>
<td>2</td>
</tr>
<tr>
<td>Tourniquet disposable</td>
<td>2</td>
</tr>
<tr>
<td>Gauze 2x2</td>
<td>4</td>
</tr>
<tr>
<td>Tegaderm medium</td>
<td>3</td>
</tr>
<tr>
<td>Gloves</td>
<td>4</td>
</tr>
<tr>
<td>Alcohol pad</td>
<td>8</td>
</tr>
<tr>
<td>18G Needle 1 1/2”</td>
<td>2</td>
</tr>
<tr>
<td>Syringe 10cc</td>
<td>2</td>
</tr>
<tr>
<td>IV Cap/microclave</td>
<td>3</td>
</tr>
<tr>
<td>Tape 1/2 in clear (Durapore)</td>
<td>1</td>
</tr>
<tr>
<td>18G catheter</td>
<td>3</td>
</tr>
<tr>
<td>22G catheter</td>
<td>3</td>
</tr>
<tr>
<td>Chux Pad (May be in Gutter)</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note: 1L may be moved to outside IV Molle supplement for ease of access, available upon request in Star City. Supplement carries 1L plus IV start kit (not pictured)
## Landing Supplement Pack

<table>
<thead>
<tr>
<th>Upper Mesh Pouch</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mist fan</td>
<td>1</td>
</tr>
<tr>
<td>Heat Pack/Cold Pack (as required)</td>
<td>2</td>
</tr>
<tr>
<td>Towel in Ziplock</td>
<td>1</td>
</tr>
<tr>
<td>Wet wipe - Antibacterial Pack</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lower Mesh Pouch</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Emesis bag</td>
<td>4</td>
</tr>
<tr>
<td>Nitrile Gloves Large</td>
<td>4</td>
</tr>
<tr>
<td>Ziplock bags quart size</td>
<td>2</td>
</tr>
<tr>
<td>Ziplock bags gallon size</td>
<td>2</td>
</tr>
<tr>
<td>Tissue Pack</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plastic Insert #1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenergan IM 25mg/1ml vial</td>
<td>2</td>
</tr>
<tr>
<td>20-22G needle 1.5”</td>
<td>3</td>
</tr>
<tr>
<td>Syringe 3ml</td>
<td>2</td>
</tr>
<tr>
<td>Alcohol Prep Wipes</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plastic Insert #2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ondansetron 4mg SL ODT (Zofran)</td>
<td>8</td>
</tr>
<tr>
<td>Meclizine 25mg PO</td>
<td>6</td>
</tr>
<tr>
<td>Calcium Carbonate 500mg Tabs</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plastic Insert #3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tylenol 500mg PO</td>
<td>10</td>
</tr>
<tr>
<td>Ibuprofen 200mg PO</td>
<td>20</td>
</tr>
<tr>
<td>Artificial Tears</td>
<td>1</td>
</tr>
<tr>
<td>Afrin nasal spray</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plastic Insert #4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
<td>2</td>
</tr>
<tr>
<td>Ear plugs - pair</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plastic Insert #5</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Foley Catheter 16Fr</td>
<td>1</td>
</tr>
<tr>
<td>10cc syringe</td>
<td>1</td>
</tr>
<tr>
<td>Lidocaine Jelly 2% 30ml tube</td>
<td>1</td>
</tr>
<tr>
<td>Providone-Iodine Swabsticks</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Back Plastic Pouch</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Face Mask</td>
<td>5</td>
</tr>
<tr>
<td>Foley Leg Bag (Bard Dispoz-A-Bag)</td>
<td>1</td>
</tr>
<tr>
<td>Sterile Gloves</td>
<td>1</td>
</tr>
</tbody>
</table>
### Launch Supplement Pack

**Upper Mesh Pouch**
- Wet Wipe Pack - antibacterial: 2
- Gloves nitrile large: 8
- Afrin nasal spray: 2
- Digital thermometer + sheathes(#7): 1
- Band aids: 10
- Bacitracin Packets: 5
- Fleets Enema: 2

**Lower Mesh Pouch**
- Tape 1” cloth: 1
- Coban 2” roll: 1
- Ziplock bag quart: 5
- Tissue Pack: 2

**Plastic Insert #1**
- Ibuprofen 200mg PO: 20
- Aspirin 325mg PO: 10
- Tylenol 500mg PO: 10

**Plastic Insert #2**
- Ambien 10mg PO: 10
- Sonata 10mg PO: 10
- Omeprazole 20mg: 10
- Calcium Carbonate 500mg Tabs: 20
- Loperamide 2mg PO: 10
- Loratadine 10mg PO: 10

**Plastic Insert #3**
- Olopatadine (Patanol) Opth: 1
- Ciprofloxacin opth 0.3% 1 bottle 5ml: 1
- Clotrimazole (Lotrimin) cream 0.42oz: 1
- Fluocinonide 0.05% cream 15 gram: 1
- Throat Lozenges: 8
- Artificial Tears 15ml bottle: 2

**Plastic Insert #4**
- Fluconazole 150mg PO: 1
- Clindamycin 300mg PO: 10
- Tinidazole 500mg PO: 4
- Doxycycline 150mg PO: 14
- Ciprofloxacin 500mg PO: 14
- Tamiflu 75mg PO - Packet of #10: 3
- Valtrex 500mg: 8

**Plastic Insert #5**
- Phenergan 50mg IM: 2
- Ondansetron 4mg SL ODT: 6
- Ceftriaxone 1mg IV: 2
- Sterile Water for Injection: 2
- Meclizine 25mg PO: 6

**Back Plastic Pouch**
- Nasal packing: 1
- Nasal Saline 45ml bottle: 1
- Tongue depressor: 2
- Qtips: 2
- Packages for pills: 10
- Emesis Bags: 2
- Ear plugs: 2
- Chapstick: 2
- Ziplock bag quart: 5
- Dental crown replacement kit: 1
- IM Injection Kit: 1
- Syringe 3ml: 2
- Needle 20G 1.5”: 2
- Alcohol Prep Pads: 4
Star City
Thank you

ronak.v.shah@nasa.gov
Topics

• Hazards of spaceflight
• Physiological changes in flight
• Crew training (CMO)
• Crew training NBL, hyperbaric/hypobaric medicine
• T-38 CRM – best realtime training.
• Ground support Houston - Preflight, Inflight, Postflight
• Ground support Zvozdny Gorodok (Star City), Russia
• Launch and Landing Operations, Kazakhstan
• LSAH program, the long game