Space Medicine: Past, Present and Future

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Space Shuttle Endeavour docked to the Destiny laboratory of the International Space Station.
Don’t stand here during launch
Space Motion Sickness (SMS) or Space Adaptation Syndrome
Visual-Intracranial Pressure

- What is the problem?
  - Optic Disc Edema, Globe Flattening, Choroidal Folds, Hyperopic Shifts and Raised Intracranial Pressure has occurred in Astronauts During and After Long Duration Space Flight

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Panoptic Fundoscopy
Increased Optic Nerve Sheath Diameter seen on-orbit
Flattening of Posterior Wall – most likely location of Choroidal Folds if any exist
Elevation of Optic Disc
Papilledema (red arrow)
Flattened globe (blue arrows)
Distended optic sheath (yellow arrow)
Cardiovascular Effects

• Increase in ventricular size initially
  – Major increase in preload
  – Inhibition of erythropoietin
  – Fluid shift into the upper thorax and head

• Increased GFR prompts a diuresis
  – Eventual decrease in preload
  – Down regulation of erythropoietin causes a spaceflight anemia.
Fluid Shift

a. On Earth, gravity exerts a **downward force** to keep fluids flowing to the lower body (A)

b. In space, the fluids tend to **redistribute** toward the chest and upper body (B). This is responsible for the face congestion. At this point, the body detects a “flood” in and around the heart

c. The body rids itself of this perceived “excess” fluid. The body functions with less fluid and the heart becomes **smaller** (C)

d. Upon return to Earth, gravity again pulls the fluid **downward**, but there is not enough fluid to function normally on Earth (D)
Neurovestibular

Vestibular Organs

Proprioception

Muscles

Tendons and Joints

Vision

Skin
Vertical Pursuit Tracking with Head and Eye

L - 10
EYE
HEAD
GAZE
TARGET

R + 0
EYE
HEAD
GAZE
TARGET

20°
1 Sec
Musculoskeletal

- Acute –
  - Postural change with stretching of tendons and ligaments.
  - Increase in on-orbit height by 2-6 cm
Effects of Spaceflight on Muscle

- Decrease in **body mass**
- Decrease in **leg volume**
- Atrophy of the **antigravity** muscles (thigh, calf)
  - decrease in leg strength
  - **extensor** muscles more affected than flexor muscles

- Data showed an increase in number of **Type II**, “fast twitch” muscle fibers (those which are useful for quick body movements but more prone to fatigue)
Musculoskeletal

• Chronic –
  – Decrease in weight bearing causes muscle atrophy and bone demineralization, 1% - 2.4% per month in lower extremities and spine, with increased urine and fecal calcium
  • A direct effect of microgravity is the loss of mechanical stress on the skeletal system

Loss of Bone Mineral Density

Bone Density Loss of 1-2.4% per month in the weight bearing areas, with the hips and lumbar spine being the highest areas. But density is only ½ of the story…matrix architecture changes are also a concern, ie- Quality as well as quantity of bone.
Immune System

• Depression of lymphocyte function affects at least 50% of space crew members
  – Decreased lymphocyte response to mitogens in cosmonauts after space flight was reported for the first time in the early 1970s by Soviet immunologists

Hematopoietic system

• Reduction in Circulating Red Blood Cell mass
  – “Space Flight Anemia”


Behavioral/Psycho-Social

Changes in crew mood, morale, and circadian rhythm

- **Symptoms** - Fatigue and irritability
- **Causes**
  - Work load
  - Sleep habits and facilities
  - Crew personalities, “crew space”, and cultural differences
  - Temperature
  - Noise
  - Odors
  - Atmosphere
  - Diet
  - Lack of family contact
Radiation

• Exposure based on orbital altitude/inclination, duration, and solar activity

• Crewmembers are radiation workers
  • Limits for mission and career exposure are set by the National Council on Radiation Protection

• As Low As Reasonably Achievable (ALARA) principle for mission planning

• Exposure monitored by active and passive dosimeters
Countermeasures

• Cardiovascular
  – Fluid loading
  – Lower Body Negative Pressure
  – G-suits and Liquid Cooling Garment
  – Exercise
  – Medication
Behavioral Health and Performance

Team Building Training

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Communications

“Care Packages”

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Levels of Care

- Sure you can do major surgery. It is feasible. But should you?
- Will there be prophylactic surgery on long duration Moon and Mars explorers (ie: appendectomy)?
- Will your consumables limit your ability to provide critical care?
Pragmatic Tenets

• Mass
• Power
• Volume
• Time
• Money
• Risk
Application of the Pragmatic Tenets

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Futuristic?

Actually, it has already been done.

EKG in Heads Up Display

CPOD, NASA Ames

NASA Houghton Mars Project
Questions?
References