Chapter 183

Space Medicine

AS Mohan

“It is expected that despite fluid shift and consequent loss of body mass in the early stage of space flight, the cardiovascular system adopts to the new environment as the astronauts continue to stay in space. In the case of bones, it is reported that 3.2% of average bone loss after nearly 10 days of weightlessness, primarily through the excessive secretion of calcium and phosphorous in urine.

The loss of calcium in urine may produce stones in urinary bladder, which may give severe pain. Counter measures include onboard exercise with treadmill and ergometer. Another effect of the microgravity relates to rapid degradation of certain muscular fibers leading to their atrophy. The necessary exercise to prevent this should be designed to expend less than 30% of maximum muscle power continuously over a long duration.

Other important issues of microgravity environment on the human body include, space motion sickness, which is characterized by headaches, nausea and eventually, vomiting as well as effect resulting from isolated space environment affecting psychology.

Mixed up in Space

Humans can become confused and disoriented (and even a little queasy) in an alien world where up and down have no meaning.

On Earth, we always know which way is up because gravity tells us. Sensors in the inner ear, which are part of the body’s vestibular system, can feel the pull of gravity. They signal the brain with information about our body’s orientation.

In space, however, the vestibular system does not sense the familiar pull of gravity. The world can suddenly seem topsy-turvy.

The vestibular system is a fluid-filled network of canals and chambers deep within the human ear that help us keep our balance and sense, which way is up.

The vestibular system is not the only one affected by the absence of weight. The proprioceptive system, that is, nerves in the body’s joints and muscles that tell us where our arms and legs are without having to look, can also be fooled. Without the stresses in the joints usually caused by the pull of gravity, this sense is sometimes dampened.

Gravity Hurts

Strange things can happen to the human body when people venture into space—and the familiar pull of gravity vanishes.

When astronauts return from long-term stints in space, they sometimes need to be carried away in stretchers.

Gravity is not just a force, it is also a signal, a signal that tells the body how to act. For one thing, it tells muscles and bones how strong they must be. In zero-gravity, muscles atrophy quickly, because the body perceives it does not need them. The muscles used to fight...
Miscellaneous

Gravity like those in the calves and spine, which maintains posture, can lose around 20% of their mass if you do not use them. Muscle mass can vanish at a rate as high as 5% a week.

For bones, the loss can be even more extreme. Bones in space atrophy at a rate of about 1% a month and models suggest that the total loss could reach 40–60%.

Blood feels gravity, too. On the Earth, blood pools in the feet. When people stand, the blood pressure in their feet can be high, about 200 mm Hg (millimeters of mercury). In space, where the familiar pull of gravity is missing, the head-to-toe gradient vanishes. Blood pressure equalizes and becomes about 100 mm Hg throughout the body. That is why astronauts can look odd: their faces, filled with fluid, puff up and their legs, which can lose about a liter of fluid each, thinned out.

Cell Wars

Immune cells versus invaders: it is a war going on in every healthy human body. When the combatants travel to space, say NASA scientists, curious things happen.

In space, our immune system functions differently. This complex system consists, essentially of disease-fighting cells that can travel throughout the body. There are many kinds of immune cells; two of the most important are: (1) B-cells, which send out antibodies, proteins that latch onto germs or other problem-causing invaders, flagging them as invaders to be destroyed and (2) T-cells, which are the soldiers of the system, physically attacking and destroying pathogens.

In space, these cells do not work the way they do on the ground. T-cells, for example, do not multiply properly; there are not as many of them as there should be. They cannot move well. They do not signal each other as effectively. Overall, they seem less able to destroy invading germs.

PHYSIOLOGICAL ISSUES

Physiological issues include the following:

- Space motion sickness
- Cardiovascular
- Neurovestibular
- Musculoskeletal
- Behavioral/psychosocial.

Space Motion Sickness

Incidence
- Affects approximately 70% of crewmembers
- Cases severe (10%).

Symptoms
- From loss of appetite to nausea and vomiting.

Time Course
- Onset from main engine cutoff (MECO) (The time at which the main engines of a launch vehicle are commanded to stop firing) to 24 hours; peak symptom 24–48 hours; symptoms resolve by 72–96 hours

Causes
- Neurovestibular—otolith mismatch, sensory conflicts
- Fluid shift.

Treatment
- Decreased activity
- One-gravity orientation: When accelerating an object with mass, this object experiences a force that is equal to gravity, even while it is not in a field of gravity. Accelerating an object with 9.8 m/s is setting one-gravity on it.
- Medication [phenergan intramuscularly (IM)].

Cardiovascular

Changes in redistribution of body fluids cause inability of the body to adapt to rapid circulatory changes, producing orthostatic symptoms postflight changes.

Symptoms
- Dizziness, lightheadedness.

Time Course
- From reentry to several hours postlanding.

Causes
- Fluid shifts
- Baroreceptor.

Treatment
- Fluid loading
- On-orbit exercise benefits: The equipment astronaut’s use is different than what we use on Earth. Lifting 200 pounds on Earth may be a lot of work, but in space it is easy. The 200 pounds appear to weigh nothing. Therefore, exercise equipment needs to be specially designed for use in space so that astronauts will receive the workout needed.
- Liquid cooling garment
- Medications.

Neurovestibular

Weightless environment provides different environment to otolith organs of inner ear. Therefore, signals from the otolith organs no longer correspond with visual and other sensory signals sent to brain. After a few days in space, astronaut begins to adapt to new neural input. On return to earth’s gravity, he/she is confronted with undoing changes in neurovestibular responses developed in space.

Incidence
- All crewmembers are affected to some degree.

Symptoms
- From vertigo and unstable gait to nausea and vomiting
- Disturbed hand-eye coordination.

Time course
- From landing to 48–72 hours postlanding.

Causes
- Neurovestibular—otolith and proprioception readaptation.

Treatment
- Avoid rapid head movements
- Slow but progressive increase in activity
- Medication (phenergan, antivert).

Musculoskeletal

The loss of bone mass that many people experience in space could eventually weaken the bone and so present problems when the person returns to the Earth.

Weakening of the bones due to the progressive loss of bone mass is a potentially serious side-effect of extended spaceflight. Studies of cosmonauts and astronauts who spent many months on space
station Mir revealed that space travelers can lose (on average) 1 to 2 percent of bone mass each month. Spacefarers typically experience bone loss in the lower halves of their bodies, particularly in the lumbar vertebrae and the leg bones. Diminishing bone mass also triggers a rise in calcium levels in the blood, which increases the risk of kidney stones.

**Incidence**

Seen in long term residents of space.

**Symptoms**

- Back pains
- Vertigo

**Time Course**

The 1 to 2 percent per month loss is an estimate of bone loss -- an average value. Certain individuals on six month flights have lost as much as 20 percent of bone mass throughout their lower extremities.

**Causes**

- Bones no longer have to fight against Earth’s gravity during locomotion
- Less mechanical strain is applied to the skeletal system
- So reduced stress on bones.

**Treatment**

- Exercise
- Drugs
- Dietary modifications
- Inertia suits such as the Soviet “Penguin” suit (Russian anti-zero-G suit looks like the standard Russian blue in-flight suit, but has additional elastic bands and pulleys that created artificial force against which the body could work. This ameliorated the deterioration of muscles and bones that occur in long-term zero gravity. The Penguin suit was routinely worn during all long-term flights.

**Behavioral/Psychosocial**

Changes in crew mood, morale and circadian.

**Incidence**

- Affects all crewmembers to some degree.

**Symptoms**

- Fatigue and irritability, performance.

**Time Course**

- Depends on flight plan.

**Causes**

- Work load
- Sleep habits and facilities
- Crew personalities, "crew space" and cultural differences
- Temperature
- Noise
- Odors
- Atmosphere
- Diet
- Lack of family contact.

**Treatment**

- Treat causes.

**CONCLUSION**

Manned space missions used to be the dream of mankind for years, but became reality with the blast-off by Yuri Gagarin in 1961 and the first small steps on the moon by Neil Armstrong on Apollo 11. Since then, human activity in space has increased steadily. More than 200 people have been to space, and the duration of stays in space has progressed from 2 hours to more than a year. Now, we are entering a new era: the 21st century International Space Station (ISS). Those who have been to space so far are highly specialized, dedicated "astronauts", but in the 21st century, common citizens will be able to travel and sight—see or to live in space. However, before space can become a safe, habitable place, we must solve so many problems. Here, we have a powerful tool, which will establish the countermeasures to overcome the physiological effects in space and that is “Space Medicine”.

**BIBLIOGRAPHY**