מבוא לרפואה תעופתית

ד"ר יחזקאל קן
THIS IS AEROSPACE MEDICINE
AEROSPACE MEDICINE

Branch of Preventive Medicine that deals with the clinical and preventive medical requirements of man in atmospheric flight and space
Approach to Aerospace Medicine

AEROSPACE
Normal Physiology
Abnormal environment

CLASSICAL
Abnormal Physiology
Normal environment
With the advent of powered flight at the beginning of the 20th century, there was a need for selection of those who wished to fly.
Fitness criteria were developed, and the determination of who met the criteria and who did not created the need for a physician trained to make this determination.
Initially this was driven by a need for qualified military pilots to fly planes in war.
AVIATION MEDICINE

- Main function was to first develop and then apply physical qualifications for flight duty
- Driven by high losses of life due to physically unqualified pilots
During World War II many technologic advances led to increasing functions in research to develop means of extending man’s ability to function in an increasingly hostile environment.

Led to aeromedical research
Increasing numbers of aircrew needed to man the warfighting aircraft
After World War II the technologic advances were applied to the airline industry. Increases in aircrew led to increases in civilian aviation medicine.
In the 1960’s advances were made to meet the challenge of manned flight beyond the earth’s atmosphere. . .Aviation Medicine evolved to Aerospace Medicine
WHAT IS AVIATION PHYSIOLOGY?
The physiology of a normal individual who works in the hostile environment of flight
Man is an earth-bound creature who must have protection to enter the hostile environment of atmospheric or space flight.
Environmental Requirements
Oxygen

As altitude increases, available oxygen decreases

ARMSTRONG’S LINE

PRESSURE SUIT NEEDED

oxyGEN UNDER
PRESSURE NEEDED

TROPOPAUSE

TROPOSPHERE

Mt Everest
29,028 ft

Andes

Mt Whitney

oxyGEN
NEEDED

Highest Human Habitation...18,000 ft

Press
mm Hg

34
54
87
141
226
349
523
760

Alt in
Thou. Ft

70
60
50
40
30
20
10
0
Environmental Requirements

Oxygen

- Lack of oxygen will affect the brain and cause fatigue, sleepiness, headache, dizziness, blurred vision and will eventually cause you to lose consciousness.

- Oxygen must be provided at high altitudes.
Environmental Requirements

Oxygen

- A pilot must be able to recognize when problems are due to lack of oxygen
- Altitude chamber training helps aircrew to discover their own hypoxia symptoms
Dalton’s Law

\[ P_T = P_1 + P_2 + P_3 + \ldots + P_n \]
Environmental Requirements

- Normal atmospheric pressure at sea level is 760 mm Hg
- As you go up in altitude, atmospheric pressure decreases.

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<thead>
<tr>
<th>Press in mm Hg</th>
<th>Alt in Thou. Ft</th>
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<tr>
<td>760</td>
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OXYGEN UNDER PRESSURE NEEDED
ARMSSTRONG’S LINE
PRESSURE SUIT NEEDED
OXYGEN NEEDED
SEA LEVEL
Environmental Requirements
Pressure

- As atmospheric pressure decreases, the air tends to expand and get thinner.
- The human body has several responses to changes in atmospheric pressure.

BOYLE’S LAW $PV=nRT$
Boyle’s Law

Can also be written as:

\[ P_1 \times V_1 = P_2 \times V_2 \]

or

\[ \frac{P_1}{P_2} = \frac{V_2}{V_1} \]
There are several places in the human body where air can get trapped. The ear, the sinuses, and the stomach and intestines are a few examples.
Trapped Air

As you go up in altitude, air expands... if this air is trapped, expanding air can lead to pain. A blocked Eustachian tube could lead to pain in the middle ear.
Sinus Blocks and Ear Blocks

- There are spaces in the sinuses and middle ear where air can get trapped.
- Under normal conditions this air can escape through passages to the outside (Eustachian tube)
Trapped Air

- Usually expanding air is not a problem since it can be released.
- When you come back down after being at altitude, the expanded air gets smaller... if this occurs in a closed space it creates a vacuum effect...This is a BIG problem.
Ear Block

- If you fly with a cold these passages can swell up enough to block the passage of air, especially when you are trying to get air in to equalize pressure on descent.
- Leads to a painful ear or sinus block!

Do Not Fly with a Cold!
Other effects of pressure

- **DECOMPRESSION SICKNESS**
  - Air bubbles can form in the body if you go to high enough altitudes
  - These bubbles are made of nitrogen and usually dissolve as you descend.
Henry’s Law
(the “Coca Cola” law)

\[ M_g = k \times P \]

- \( M_g \) = mass of gas dissolved
- \( P \) = ambient pressure above liquid
Decompression Sickness

- Bubbles that do not dissolve can get trapped in the joints and cause pain (bends).

- If they form in the blood and go to the brain they can cause serious neurologic symptoms.
Decompression Sickness Prevention

- Prebreathing 100% oxygen for at least an hour before high altitude flights can decrease the amount of nitrogen in the body and decrease the chance of getting decompression sickness.

- Pressurized cabins or, if necessary, pressure suits can be used.
Decompression Sickness Treatment

- Decompression sickness can often be successfully treated in a hyperbaric chamber which dilutes out the nitrogen with high pressure concentrated oxygen

Hyperbaric Chamber, Brooks AFB, TX
Acceleration Forces
Acceleration Forces

- The very rapid rate of acceleration used in most military jet fighters and in the space vehicles imposes another hazard on the aviator.
- Acceleration results in an increase in the force of gravity on the aviator which can be up to nine times what he experiences on earth.
Acceleration Forces

• Acceleration forces tend to be directed downward, and as they increase, they cause an aviator’s blood to be pushed downward in his body, moving blood from his brain to his feet.

• If this force is not counteracted, the aviator will first lose his vision (black-out) and then consciousness (G-induced loss of consciousness or GLOC)
Positive Acceleration (+Gz) (Sustained)

- POOLING BEGINS 1-3 “G”
- GREYOUT 3-4 “G”
- BLACKOUT 4-5 “G”
- UNCONSCIOUSNESS 5-6 “G”
To counteract this force, “G” suits have been developed which squeeze the legs and abdomen during high G conditions to prevent blood from being pushed there.

G suits are made up of five interconnected bladders covering the legs and abdominal region.

Pressurization of the bladders occurs during increases in G forces.
The aviator can also do a special “straining” maneuver and tighten all his muscles. An adequate straining maneuver can be mastered during centrifuge training.

Centrifuge Facility, Brooks AFB, TX
Spatial Disorientation

- A state characterized by an erroneous sense of one’s position and motion relative to the earth’s surface
- There are three types
  - Type I: Unrecognized
  - Type II: Recognized
  - Type III: Incapacitating
Types of Spatial Disorientation

- **Type 1 “Unrecognized”**
  - The pilot does not perceive that something is wrong
  - Very dangerous in that the pilot will continue to operate his aircraft according to his misperception

- **Type 2 “Recognized”**
  - Usually recognized in the sense that the pilot knows something is wrong or he feels vertigo; but may not recognize it as spatial disorientation
  - May be that his instruments tell him something different from the “seat of the pants” sense
  - Often the pilot can correct this by “making the instruments read right”

- **Type 3 “Incapacitating”**
  - Pilot is disoriented, knows it, but can’t do anything about it
  - Overwhelmed by the strength of his vestibular response to the disorientation
Spatial Disorientation

- Vision
- Vestibular
- Seat-of-the-Pants

Senses of Orientation and Body Responses

Balance
Spatial Disorientation

While we are in contact with the earth, the pull of gravity squeezes pressure sensors in the various portions of the body, thus telling us in which direction the earth lies.
In flight, however, G-forces combine with the pull of gravity to make the seat-of-the-pants sense completely unreliable as an attitude indicator.
Spatial Disorientation

Sense rotation

SEMICIRCULAR CANALS

OTOLITH ORGANS

INNER EAR PERCEPTION PROBLEMS
Space Medicine

- Major Physiologic Issues
  - Zero Gravity
  - Space Motion Sickness
  - Cardiovascular
  - Neurovestibular
  - Musculoskeletal
  - Psychiatric
Space Medicine
Zero Gravity

- There are many problems with low gravity environments such as the zero gravity environment of space.
- Exposure to this environment over time can cause problems with the balance system leading to vomiting; problems with bone mineralization, muscle loss, and upon return to the 1 G earth, even problems with standing up!
Space Medicine
Space Motion Sickness (SMS)

- Affects 75% of crewmembers
- Symptom range from loss of appetite to nausea and vomiting
- Thought to be caused by sensory conflict or fluid shifts
Lightheadedness, dizziness, and fainting sometimes occur post-flight (in about 20% of aircrew).

Changes occur during exposure to the zero-G environment in space:
- changes in the heart
- changes in body fluid distribution

Treated with fluid loading, G-suits, exercise, medications and lower body negative pressure (LBNP)

Astronaut using LBNP device to try to counteract the cardiovascular effects of space flight (from Space Physiology and Medicine 1993)
Space Medicine
Neurovestibular

- In space changes occur in the way the body senses posture and position
  - Causes problems with balance and coordination upon return to earth
  - Can be treated with a slow progressive increase in activity, slow head movements, and medications
- All crewmembers are affected to some degree
Space Medicine
Musculoskeletal

- Calcium metabolism is increased in the zero-G state leading to bone demineralization and increased excretion of calcium
  - kidney stones can form
  - increases chance of fractures
- Muscle loss occurs from lack of use of postural muscles
- Affects all, only treatment is exercise, stretching and medication
Space Medicine
Psychiatric

- Must monitor crew for changes in morale and mood
- Can be due to sleep habits, personalities, confinement, noise, odors, and lack of family contact
- Circadian rhythm disturbances can lead to the ultimate “jet lag”

On the Mir
Aerospace Medicine

- Thus, there are many problems with the abnormal environment encountered in aviation and space. The flight surgeon is just one of many highly trained individuals working to minimize the effects of these adverse effects so that man can continue to have mastery over the air and space.
תודה!