EMS Subspecialty Certification Review Course

1.4.4 Flight Physiology
1.4.4.1 Effects of altitude on patient management
1.4.4.2 Effects of altitude on healthcare providers

2025

1

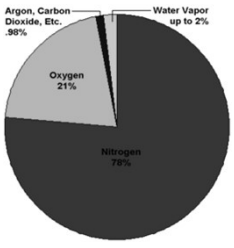
Learning Objectives

- Understand basic principles of physiologic effects of atmospheric pressure
- Understand risks to patients and caregivers due to altitude
- Understand and describe applicable physical laws of gases which may negatively affect physiology
- Understand and describe physiologic stressors of flight

2

Atmospheric Considerations

- Composition
  - 78% nitrogen, 21% oxygen at all altitudes
- Pressure is due to the weight of the gases
  - Decreases with altitude
- Gases are subject to physical laws
  - Gases in our bodies will change with the environment

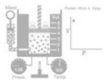


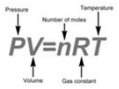
3

Flight Physiology

There are 5 basic laws of gases which affect physiology

- **Boyle**: The effect of altitude on gas volume
- **Dalton**: The effect of altitude on oxygen availability
- **Henry**: Gas equalization due to pressure changes
- **Charles:** The effect of temperature on gas volume
- **Graham:** Diffusion of gases from higher to lower concentrations





American College of Emergency Physicians
ADVANCING EMERGENCY CARE

4

Boyle's Law

- Volume is inversely proportional to pressure
  - Gases expand when pressure is decreased
    - Ascending in a pool, bubbles get bigger
  - Gas expansion and contraction problems
    - Pneumothorax
    - Middle ear & sinuses
    - Stomach & intestines
    - Medical appliance with cuff/balloon
    - Any air in non-communicating space

American College of Emergency Physicians
ADVANCING EMERGENCY CARE

5

Dalton's Law

- Total barometric pressure = sum of partial pressures (pressure of each gas present)
  - Partial pressure = (Total pressure)(% of gas)

    Without adequate partial pressure of oxygen, you cannot absorb oxygen in your lungs
- As you ascend, the percentage of oxygen remains constant, but partial pressures decreases

American College of Emergency Physicians
ADVANCING EMERGENCY CARE

6

Dalton's Law

- Total barometric pressure = sum of partial pressures
  - Partial pressure = (Total pressure)(% of gas)
- At sea level P_{total} =760mmHg
  - P_{O2}= 760mmHg x 21% = 160mmHg
  - @ 10Kft = 520mmHg x 21% =109mmHg

7

Henry's Law

- The amount of gas dissolved in a liquid is a function of the applied pressure
- When pressure is released, gas comes out of solution ir the form of bubbles
- These bubbles in the body cause evolved gas problems (decompression sickness)
- Divers should wait to fly until 12-24 hours after diving

8

Graham's Law

- Gases diffuse from higher to lower concentrations
  - Impacts normal gas exchange and cellular respiration
- Rate of diffusion of a gas through a medium is:
  - Directly related to the solubility of the gas
  - Inversely proportional to the square root of its density

9

Bonus: Gay-Lussac's Law

- Pressure and temperature are directly related when volume is constant
- E.g. Pressure in an oxygen tank decreases as the temperature decreases

10

Physiological Zones

- Physiological Zone – sea level to 10,000'
  - We can adapt in this zone
- Physiological Deficient Zone – 10,000' to 50,000'
  - Majority of commercial flying
  - Hypoxia due to altitude
  - Trapped gas problems

11

And a final law… Murphy's Law

"Whatever can go wrong will go wrong,
and at the worst possible time"

If you ignore the previous gas laws, Murphy's Law applies

12

Patient Considerations

Hypoxia
Non-solid organs with trapped air
Equipment: any equipment with air chambers
Barotrauma: Ascent / Descent
G-forces
Temperature
Humidity
Vibration

13

Crew Considerations

- Hypoxia
- Dehydration
- Noise Hearing loss
- Fatigue
  - Vibration
  - G forces
  - Third spacing
- Situational Awareness / Perception

14

Take-Home Points

- Air medical transport requires increased attention to operating environment for both crew and patients
- Air operations, even at low altitudes, present a series of risks which must be proactively anticipated and managed
- Clinicians must have an understanding of aircraft limitations, operating characteristics, attributes, and safety equipment
- The effects of altitude physiology may be insidious, especially hypoxia, affecting both patients and air medical crew
- Crew resource management (CRM) is essential in all operations and especially essential in helicopter operations due to low altitude with limited recovery time

15