TOP KNIFE
FIGHTER SURGEON COURSE

173 Fighter Wing
Kingsley Field Oregon

RSV-1B4

DECOMPRESSION SICKNESS AND HYPOXIA

Criterion Referenced Objectives

- Differentiate between Decompression Sickness (DCS) Types I and II in the setting of Air Force flying operations
- Describe appropriate medical treatment for DCS, and distinguish between cases that do or do not require hyperbaric treatment
- Describe types of hypoxia and predict when in flying operations it is most likely to occur
- Summarize the treatment of hypoxia

Overview

- Define DCS
- Predict when DCS will be a problem
- Describe predisposing factors to DCS
- Describe Type I and Type II DCS
- Describe DCS treatment protocols

Overview

- Define hypoxia
- Describe types of hypoxia
- Predict when hypoxia will be a problem
- Describe predisposing factors to hypoxia
- Describe hypoxia treatment
- Describe oxygen paradox
- Describe hypoxia prophylaxis

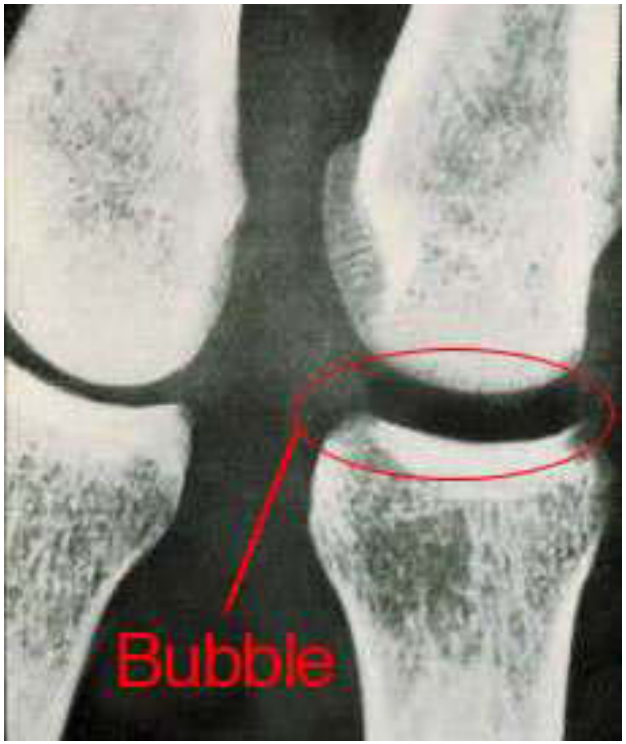
DCS Definition

Decompression sickness (DCS) is an illness caused by reduced atmospheric pressure on the body that results in formation of bubbles of inert gas (nitrogen) within body tissues. These bubbles result in symptoms of DCS, which can range from mild joint pain to permanent neurologic deficits to death.

- Flight Surgeon's Guide

DCS – The Problem

- Mechanical effects of bubbles
  - Displace/deform adjacent tissue
    - If too great can tear tissues
  - Impinge upon nerves → pain
  - Obstruct vessels → ischemia (CNS, pulmonary, cardiac)



DCS – The Problem

- Bubble – bubble interface effects
  - Bubbles look like foreign invaders to the immune system
  - Inflammatory mediators released
  - RBCs and platelets congregate → tissue ischemia
  - Extravasation of intravascular fluids → hemoconcentration → reduced blood flow → increase fibrinogen → cycle worsens

USAF DCS Risk

- Altitude chamber exposure
- Unpressurized aircraft
- High altitude aircraft with insufficient pressurization
- Loss of pressurization in aircraft
- Class A-D mishaps: 8 cases 2000-2012

Factors Predisposing to DCS

- Altitude
- Rate of ascent
- Time at altitude
- Exercise
- Body fat
- Prior injury
- Age
- Gender?
- Air temperature
- Repeated exposure
- Diving
- Individual variability

Type I DCS – Mild

- Simple Bends - Joint Pain
- Cutaneous
  - Cutis Marmorata – “marbled skin,” may precede circulatory collapse
  - Subcutaneous emphysema
  - Lymphatic obstruction- N gas bubbles block lymphatics
  - Scarlitiniform rash
  - Pruritis

Type II DCS - Severe

- Neurological
  - Usually brain affected when altitude-related vs spinal cord when diving
  - Spotty sensory and motor signs, no one focus
  - Headache
  - Visual disturbances
  - Personality/affect changes
  - Mental status changes

Type II DCS - Severe

- Chokes
  - Pulmonary gas emboli
  - Stabbing central chest pain
  - Dyspnea
  - Non-productive cough

Type II DCS - Severe

- Circulatory collapse
  - Rare shock following other manifestation
  - Direct involvement vasomotor regulatory center?
  - Overwhelming release vasoactive substances?
  - Massive vessel endothelial damage by the bubbles?
    - Subsequent loss of intravascular fluid
  - **Hallmark: IV fluids don't help, immediate third spacing**

Treating DCS

- Get rid of bubbles
  - Get on the ground (back to roughly 1 ATM)
  - Get on the oxygen – 100%
  - Get help from a hyperbarics doc
  - Get “under water” (more than 1 ATM i.e. hyperbaric chamber)

Type I DCS Treatment Protocol

- ABCs
- Continue 100% O2 via tight fitting aviator's mask
- Immobilize painful limb(s)
- VS q 15 minutes

Type I DCS Treatment Protocol

- Hx and PE
  - Complete neurological exam
- Normal exam
  - Continue O2
- Abnormal exam
  - (motor/sensory deficit or MS change)
  - Continue O2 and go to severe/Type II DCS treatment protocol

Type I DCS Treatment Protocol

- Continue 100% O2 minimum of 2 hours
- Reevaluate continuously
- F/U in flight medicine office next day
- DNIF minimum 72 hours
- RTFS only after consult with Brooks HBPOC

Type I DCS Treatment Protocol

- Symptoms resolve
  - Continue O2 for at least 1 hour after resolution
- Symptoms remain, worsen, or recur
  - Go to severe DCS treatment protocol
- Outpatient management
  - Oral hydration
  - No exercise/strenuous activity at least 24 hours
  - No alcohol

Type II DCS Treatment Protocol

- ABCs
- Continue 100% O2 via aviator, nonrebreather, or anesthesia mask
- Immobilize painful limb(s)
- Place in supine position
- VS q 15 minutes

Type II DCS Treatment Protocol

- Hx and PE – look for signs of barotrauma
- Complete neurological exam, repeat q 15 min
- If neurologic deficit, place in head down left lateral decubitus position
- IV access, bolus with 1L NS or LR then continue 125-150 mL/hr
- ECG monitor and pulsox
- DO NOT GIVE ASPIRIN (microvascular hemorrhage)

Type II DCS Treatment Protocol

- If severe neurologic symptoms and immediate transport to hyperbaric chamber not available, consider IV steroids after consult with Brooks HBPOC
- Initiate transport to hyperbaric chamber

Contact Information

- USAFSAM Hyperbaric Center – Brooks AFB, TX
  - DSN: 554-3483 (During Duty Hours)
  - DSN: 554-5990 (After Duty Hours)
  - COM: (210) 292-3483/5990 (Ask for Hyperbarics Doctor on Call)
- GPMRC – Scott AFB, IL
  - DSN: 779-7157
  - COM: (618) 229-7157

Hypoxia Definition

Hypoxia in aviation is a syndrome that is usually acute and results from inadequate oxygenation of tissues secondary to a decreased partial pressure of oxygen in the inspired air.

- Flight Surgeon's Guide

Types of Hypoxia

- Hypoxic – Decreased partial pressure of O_2 in the lungs
  - Most common type in aviators
- Hypemic (anemic) – Decreased O_2 -carrying capacity of blood
- Histotoxic – Toxins interfere with tissue's ability to utilize O_2
- Stagnant – Circulation impaired

Hypoxia Stages

- **Indifferent stage** – dark adaptation limited
- **Compensatory stage** – unless prolonged exposure or exercise undertaken, effects are latent secondary to physiologic compensation (increased respiration and cardiac output)

Hypoxia Stages

- **Disturbance stage** – compensation fails
  - Subjective symptoms: fatigue, lassitude, somnolence, dizziness, headache, dyspnea, euphoria
  - Visual and intellectual impairment
  - Disinhibited personality
  - Psychomotor impairment
  - Hyperventilation
  - Cyanosis

Hypoxia Stages

- **Critical stage** – Loss of consciousness
  - Circulatory failure (fainter), more common with prolonged hypoxia
  - CNS failure (non-fainter), maintains BP, more common with acute hypoxia
  - Time of useful consciousness decreases with altitude
  - Convulsions and respiratory failure possible with either

Hypoxia – Stages

Stage	Breathing Air (Altitude MSL)	Breathing 100% O2 (Altitude MSL)	Arterial O2 Saturation
Indifferent	0 to 10,000	34,000 to 39,000	95 – 90%
Compensatory	10,000 to 15,000	39,000 to 42,500	90 – 80%
Disturbance	15,000 to 20,000	42,500 to 44,800	80 – 70%
Critical	20,000 to 23,000	44,800 to 45,500	70 – 60%

Hypoxia and Time of Useful Consciousness

Altitude	Time of Useful Consciousness
FL 180	20 to 30 Min
FL 220	10 Min
FL 250	3 to 5 Min
FL 280	2.5 to 3 Min
FL 300	1 to 2 Min
FL 350	1.5 to 2 Min
FL 400	0.5 to 1 Min
FL 430	9 to 12 Sec
FL 500 and above	9 to 12 Sec

Possible Symptoms of Hypoxia

- Air hunger/oxygen want
- Apprehension
- Headache
- Dizziness
- Fatigue
- Nausea
- Hot and cold flashes
- Blurred vision
- Tunnel vision
- Tingling and numbness
- Euphoria and belligerence

Factors Influencing Hypoxia

- Altitude
- Rate of ascent
- Duration at altitude
- Ambient temperature (hotter is worse)
- Physical activity (exertion is worse)
- Individual factors
  - Fitness, illness (e.g. pneumonia, anemia), EtOH and narcotics, tolerance, acclimatization, emotions

Treatment of Hypoxia

- 100% oxygen will rapidly reverse symptoms
- In the aircraft, gang load regulator:
  - Continue aviator's mask
  - Red switch on regulator to EMERGENCY
  - White switch to 100%
  - Check that green switch is ON or PBG (should always be there when jet fuel is burning)

Oxygen Paradox

- Transient worsening of hypoxia symptoms
  - Begins immediately after initiating 100% O_2
  - Often so subtle that it goes unnoticed
  - Lasts 15-60 seconds
  - In **extreme** cases, seizures and/or LOC with prolonged recovery time
  - Resolves spontaneously with oxygen

Oxygen Paradox

- Physiologic response
  - Hypoxia → hyperventilation → hypocapnea (with ↓ respiratory drive and ↓ respiratory rate)
  - 100% O_2 → dilation of pulmonary vascular bed → hypotension
  - Hypocapnea and hypotension → ↓ cerebral blood flow
  - ↓ respiratory rate → ↑ pCO_2 → normal respirations, ↑ cerebral blood flow

Oxygen Paradox

- Considered physiologic event
  - No DNIF, no workup required
  - BUT potentially catastrophic if severe and occurs in single seat airframe
  - Also potentially confusing to other aircrew or treatment personnel if not aware and willing to wait it out
  - THEREFORE avoid with good PRICE check, appropriate use of equipment

Hypoxia Prophylaxis

- Pressure breathing for altitude (PBA) may be necessary for ops above FL 400
  - 100% O_2, continuous positive pressure
  - Requires forceful expiration, results in fatigue
  - Can cause extravasation of fluids
  - Counterpressure garments used
  - Considered an emergency technique only
- Pressure suits mandatory over FL 500

Summary

- DCS
  - Predisposing factors
  - Type I and Type II DCS
  - Treatment protocols
- Hypoxia
  - Types of hypoxia
  - Predisposing factors
  - Treatment
  - Prophylaxis
- Next slide for quiz instructions

- Go to quiz
- Enter your answers on the answer sheet
- Print only one answer sheet for entire course
- Press ESC to go back to main menu