The Neurology of Altitude

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up

down
Layers of the Atmosphere

- **Troposphere**  
  - Surface to 20,000 feet
- **Stratosphere**  
  - To 160,000 feet
- **Mesosphere**  
  - To 280,000 feet
- **Thermosphere**  
  - to 350 miles
- **Exosphere**
Oceanic pressure

• Every ten meters (33 feet) of descent is equivalent to gaining one atmosphere pressure.
Oceanic Temperature

- Temperature
  Relatively constant at surface down to 90 feet
  Temperature drops rapidly at the thermocline
Acute Decompression Sickness
“The Bends”
(aka “bubble trouble”)

- Unexpected depressurization
- Flight or ascent after diving
- Nonpressurized flight
- Rapid diving ascent
Acute Decompression Sickness

- Prevention: Be aware of depth and duration of dive, and of ascent rate
Acute Decompression Sickness

- Neurologic symptoms:
  - Paresthesia, amnesia, visual changes,
  - behavioral changes, seizures,
  - unconsciousness
Acute Decompression Sickness

Symptoms by frequency (US Navy):

- Local joint pain 89%
- Arm symptoms 70%
- Leg symptoms 30%
- Dizziness 5.3%
- Paralysis 2.3%
- Shortness of breath 1.6%
- Unconsciousness 0.5%
Acute Decompression Sickness

Treatment:
Descend to or remain at depth until equilibrated and ascend appropriately.
Nitrogen Narcosis

L’ivresse des grandes profondeurs (”Rapture of the deep”) J. Cousteau, 1953
Nitrogen Narcosis

Nitrogen, oxygen, and hydrogen cause decreases in mental function (as can the noble gases, except helium and neon), but the effect on psychomotor function is inconsistent.

Carbon dioxide consistently causes a decrease in mental as well as psychomotor function.
Nitrogen Narcosis

- **Mechanism**
  - Seems to be a direct effect of gas dissolving in nerve membrane with resultant disruption of transmission
  - Causes an alteration in lipid bilayer permeability to ion movement (similar to effect of ethanol)
  - The greater the lipid solubility, the less partial pressure is needed
Nitrogen Narcosis

- **0-33**  
  No symptoms

- **33-100**  
  Mild functional impairment, mild euphoria

- **100-165**  
  Impaired reasoning, acalculia, overconfidence

- **165-230**  
  Drowsiness, hallucinations, severe response delay

- **230-300**  
  Memory loss, stupefaction

- **300+**  
  Mania-depression, unconsciousness, death
Nitrogen Narcosis

- The “martini law”
  - Every ten meters below 20 meters is equivalent to one martini
Nitrogen Narcosis: Treatment

- Limit depth of dive
- Utilize Trimix (helium, nitrogen, oxygen) or Heliox (helium, oxygen); this is “technical diving” and requires advanced certification
High Pressure Neurologic Syndrome

- Occurs in commercial divers descending below 500 feet, breathing helium oxygen mix.
- “helium tremors” include myoclonic jerks, somnolence, nausea, dizziness and decreased mental performance.
High Altitude Neurologic Syndromes

- Acute mountain sickness
- High altitude cerebral edema
- High altitude headache
- Cerebral form of high altitude pulmonary edema
- Delayed neurologic decompression sickness
- Other neurologic syndromes
High Altitude Cerebral Edema (HACE)

- Hypobaric hypoxia
- Includes acute mountain sickness and acute mountain headache
Hypobaric hypoxia

- Oxygen percentage (21%) stays the same, but pressure declines with altitude
- Night vision deteriorates at 5,000 MSL
- Above 12,000 MSL, judgment, memory alertness and coordination become impaired
- Deterioration can occur within 15 minutes at 15,000 feet
- Above 18,000 MSL decline occurs in <20 minutes; at 20,000 MSL, decline occurs in 5-10 minutes
- Hypoxic changes worsened by alcohol, carbon monoxide, anemia and certain medications (antihistamines, sedatives, analgesics) and cold temperature
HACE

Mechanism
- Hypoxic cellular damage with edema
- Starts at 6500-10,000 feet
- Majority of people have symptoms at > 14,000 feet

Symptoms
- Confusion, nausea, vomiting, fatigue, ataxia, blindness, coma

Treatment
- Descent, oxygen, diamox, sildenafil, decadron
Reversible Cerebral Vasoconstriction Syndrome

- Caused by ascent to high altitude
- Severe headache with or without neurologic findings in the setting of multifocal vasoconstriction of the cerebral arteries
Other Neurologic Syndromes

- Vestibular
  - Disturbances related to the cochlea
- Somatosensory
  - Disturbances related to the skin, joints and muscles
- Visual
  - Disturbances related to the eyes, and optic system
Vestibular dysfunction

- Mechanism
Vestibular Illusions

- The Leans
- Coriolis illusion
- Graveyard spiral
- Somatogravic illusion
- Inversion illusion
- Elevator illusion
“Controlled Flight into Terrain”
Visual illusions

- False horizon
- Autokinesis
- Optical illusions
  - Runway, featureless terrain, haze, fog
- Night vision illusions
  - Autokinesis, false horizon
Thank you!

“Captain” Doug McGirr (age 14)