High Altitude Illness, AMS, and other Environmental Injuries

Lecture 19

Unit 3

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Outcomes

At this lecture's completion, the learner will be able to:

- Integrate pathophysiological principles and the clinical presentations of environmental disorders of:
- Discuss the clinical picture and the implications for treatment of :
  - Acute Mountain Sickness and the High Altitude Syndromes
  - Lightning injuries
  - Blast injuries

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High Altitude Illness

- Incidence:
- At > 9,000 ft: 30%
- Machu Piqchu ("Lost City of the Incas")
  7,970 ft , or 2,430 m

- At > 11,000 ft: 100%
- Pike's Peak, Colorado
  14,115 ft , or 4302 m
- La Paz, Bolivia: 11,913 ft

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AMS and High Altitude Illness

- Entities (3)
  - Acute Mountain Sickness (AMS) and high altitude cerebral edema (HACE) can be thought of collectively
  - High altitude pulmonary edema (HACE)
- Risk Factors
  - Less common in women and persons over 50
  - Rate of ascent
  - Altitude
    - Especially the sleeping altitude
  - Fitness : not protective
  - Less 1/10,000 Colorado skiers contract HAPE (and HAPE is more common than HACE)

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High Altitude Illness Pathophysiology

Hypoxic ventilatory response (HVR)

- Hypoxia-induced over perfusion of the cerebral and pulmonary vascular beds with resulting:
  - ↑ hydrostatic pressures
  - ↑ interstial third-spacing and edema
  - ↑ intracranial pressure → ↑ sympathetic reflex (vasopressin; renin,…)
  - Systemic fluid retention → ↑ hydrostatic pressures in lung and brain

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Acute Mountain Sickness

An acute high altitude illness :

- Unacclimatized person
- Just traveled to altitude > 2500 m (8200 ft)
- ***HA*** and plus ***1*** or more of the following:
  - GI (N,V, anorexia)
  - Dizziness
  - Lassitude; fatigue; insomnia
- Onset usually within 1 - 6 hr

Signs: not helpful

- Cheyne-Stokes respirations (at > 9,000 ft 100% of persons)

Significance of early sx. + signs:

- Harbinger of more serious high-altitude illnesses: HACE, HAPE

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Prevention of AMS

- Acclimation : Slow, staged, 3+ days ascent
- Acetazolamide (carbonic anhydrase inhibitor; sulfa..)
  (Diamox) 250mg BID-TID ; (3) days:
  day before / day of arrival / 1day after ascent
  MOA:
  - Renal bicarb excretion
  - Metabolic acidosis
  - H+ + HCO3- <--> H2O + CO2
  - Increased respiratory drive
  - Decreased sleep-hypoventilation
  - Decreased hypoxic ventilatory response
  - Decr cerebral vasodilitation--> capillary leakage
- Other: Dexamethasone ; Ginkgo biloba
- Worse with hypoventilation (sedatives, hypnotics)

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AMS Treatment

- O2
- Avoid further ascent until symptoms resolve
- Consider descending
  - 1000 - 1500 ft : usually adequate)
- ASA, ibuprofen
- Dexamethasone 4-8 mg po, IV, IM
- Start Acetazolamide , if not already begun

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HACE
High Altitude Cerebral Edema

- Progression of AMS sx . + signs :
  - HA, N, V
- ***Ataxia***
  - a hard, end organ finding
- Stupor
- Progression to seizures, coma
- Papilledema, retinal hemorrhages
- CN palsies

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HACE Treatment

- Immediate ***descent*** (definitive Tx)
- O_2
- Dexamethasone 8-12 mg IV, IM
- Consider
  - Gamow bag (port. hyperbaric chamber)
  - Lasix 80 mg IV
  - Mannitol 0.25 – 1.0 gram/kg IV
  - Intubation and hyperventilation
- HACE Dx unlikely if:
  - Onset > 3 days after ascent
  - No HA
  - Failure to respond to O2, steroids, and descent

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HAPE
High Altitude Pulmonary Edema

- Leading cause of high altitude-related deaths
- Risk factors
  - Heavy exertion
  - Rapid ascent
  - Cold exposure
  - Excessive salt intake
  - Use of sleeping meds, sedative-hypnotics (alcohol)
  - Previous Hx of HAPE / HACE
    - believed to be due to (1) a reduced ventilatory response to hypoxia; and (2) an exaggerated pulmonary vasoconstrictive response to both hypoxia and to exercise

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Clinical Presentation of HAPE

Hackett, PH N Engl J Med 345 (2): 107, July 12, 2001
does not use a severity classification [Hultgren HN] exactly.
You may find it helpful to grade the severity: 1/2 or 2/2

Severity: mild to moderate

- Dyspnea on exertion (DOE)
- ***Dry cough***
- Fatigue
- Dusky nail beds
- Localized rales (typically beginning in right lung)
- 50% (but only 50%) have had prior AMS sx
- Occurs on the ***second*** night ["2 lungs on night 2"]
  - Rarely occurs after four nights

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Severe HAPE

- Dyspnea at rest
- Weakness and fatigue at minimal exertion
- Increasing raspy cough
- Blood tinged sputum
- HR > 110
- RR > 30
- ↑ bilateral rales
- Cyanotic nail beds and facial cyanosis
- Fever
- Severe desaturation and respiratory alkalosis

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Treatment of HAPE

- Immediate decent
- O_2
- Morphine
- Lasix
- Dexamethasone ***NOT*** helpful
- PPV with BVM or CPAP
- Beta-agonists
- Nifedipine ; sildenafil (viagra)

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HAR + HAFE

- HAR
  - High Altitude Retinopathy
- HAFE
  - Boyle's law (volume of a gas varies inversely with the pressure)
  - Non-lethal

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Lightning Injury

- Prior to Katrina: lightning caused more fatalities than most other disasters combined (150-250 deaths / yr) (world: 8 million strikes / day)
- Mechanism of injury:
  - Massive DC countershock
  - Up to 20 million V [usu. Injury << 70,000V]
  - Duration only 1-100 msec.
  - Passes over body rapidly; may spare deep tissue injury

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Lightning Morbidity and Mortality

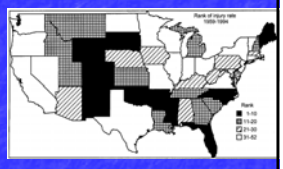
Mortality : 25%

Morbidity : 70%

Pregnancy

- fetal mortality : 2/4
- newborn mort.: 1/4

3/4



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Cause of Death in Lightning

Trauma ; electrocution can occur

Cardiac arrest

- 2° to asystole
- Often may spontaneously convert → sinus tach

Resp. arrest

- Immediate cause of death: apnea → hypoxia → VF
- ***Prolonged***, usually
- Vent. assistance required, usually Resp. arrest
- Early CPR, rather than AED

Mt Whitney

elevation 14,491' (4417 meters)

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Lightning Casualties

- Radio / Radio Equip. (1.2%)
- Farm and Heavy Equipment (5.%)
- Telephone (4.%)
- Open Fields (45.%)
- Under Trees (23.%)
- Water (13.6%)
- Golf (6.5%)
- Golf and Trees (1.7%)

Types of strike (4):
- Direct hit
- Splash
- Contact
- Step

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Lightning Scene

- DDX
  - MI
  - Assault
  - CVA
  - Seizures
- Scene : ongoing risk
  - to rescuers
  - of ACLS in the rain

Types of strike (4):
- Direct hit
- Splash
- Contact
- Step

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Lightning Triage

- " Reverse triage "
  - if there are multiple victims :
  - the "walking wounded"
    - do not need immediate attention
  - the "lifeless"
    - may survive if given CPR / ALCS
- "Walking wounded"
  - initially "uninjured" survivors can have significant neuro. sequelae (see: Cohen, M.)

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Lightning Injuries

- TM rupture (Type I blast injury)
- "Cobweb-like" flashover burns
- Clothing disintegration, partial or complete
- Neuro
  - Confusion, amnesia, paralysis, and loss of consciousness (result of the passage of current through brain)
  - Keraunoparalysis: transient paralysis with vasomotor instability (cold, mottled) and sensory disturbances of extr(s)
  - Prolonged extr. paralysis: R/O spinal cord injury
  - Fixed and dilated pupils (paralysis of iris) transient ; not necessarily serious head injury
- Hypotension
  - R/O intra-abd , thoracic hemorrhage, fx pelvis, or cord injury

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Keraunographic Markings

- Injuries commonly seen
  - TM rupture
  - Keraunoparalysis
  - Keraunographic marking:
    - transient, erythematous dendritic mark(s) on the skin
- Keraunographic marking
  - pathognomonic of lightning strike
  - If observed on unresponsive pt., indicates person was a lightning victim: pt may benefit from aggressive CPR and ALS

See: Cohen . *Acad Emerg Med* Volume 8, Number 9 893-931 http://www.aemj.org/cgi/content/full/8/9/893 [the images here and in the above article were reproduced in the article with permission for that article]

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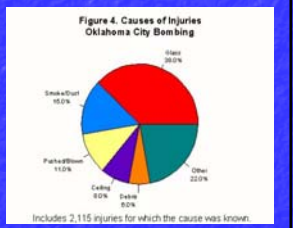
Blast Injuries



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Blast Injury Classification

- Type I
  - Pressure wave or pulse
  - Barotrauma
  - Traumatic amputation
    - 25% of severe blasts
    - High mortality
- Type II
  - Flying debris
  - Penetrating trauma
- Type III
  - Human-projectiles
  - Deceleration injury
- Type IV
  - Toxic gases; burns

Most common type I injuries

- Ear: TM rupture (15 PSI)
- Lung
  - Pneumothorax
  - Contusion
  - Air embolism
- GI : Bowel perforation
- CNS:
  - Concussion
  - Air embolism
  - Spinal cord
  - Stroke
  - Traumatic brain injury (TBI) without a direct blow to head.

  Medical experts say TBI is the signature wound of the Iraq war.

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Traumatic Brain Injury (TBI)

- "A blast creates a sudden increase in air pressure by heating and accelerating air molecules and, immediately thereafter, a sudden decrease in pressure that produces intense wind. These rapid pressure shifts can injure the brain directly, producing concussion or contusion. Air emboli can also form in blood vessels and travel to the brain, causing cerebral infarcts…" (Mayorga MA. The pathology of primary blast overpressure injury. *Toxic* 1997;121:17-28).
- "…22,600 U.S. soldiers wounded in the conflicts in Iraq, Afghanistan, and other locations as of Nov. 4, 2006, blasts have been by far the most common cause of injury, and 59% of blast-exposed patients at Walter Reed have been found to have a TBI …". - Traumatic Brain Injury in the War Zone Okie, S, *N Engl J Med* 2005; 352: 2043-2057
- "…Kevlar body armor and helmets are one reason for the high proportion of TBIs among soldiers wounded …." *ibid*
- "...because mortality from brain injuries among U.S. combatants in Vietnam was 75 % or greater, soldiers with brain injuries made up only a small fraction of the casualties treated in hospitals …" *ibid*

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Patient and Event History in Blast

- History:
  - nature of explosive
  - closed / open
  - distance
- Symptoms :
  - hearing↓
  - dyspnea
  - chest pain
  - hemoptysis
  - LOC
  - stroke sx

History:

Conduction medium (water)

- Hollow organ (ear, lung, GI, CNS) injuries will occur :
  - with > severity in water and
  - at > distances in water (than in air)

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Blast Injury Treatment

- A / C
  - Facial fractures / FB
- B
  - O2 100%
  - R/O pnthx. / tension pnthx.
  - Cautious ventilation (Risk of air embolism)
- C : IV
  - Support BP
  - Monitor $_4$
- D :
  - Disability (cortex / brain stem / cord)
  - Drums

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Blast Injuries

D:

- Assess the ***D*** rums (as an indicator of psi.)
  - If TMs are intact:
    - pulmonary injury very unlikely
  - TM rupture:
    - if P > 15psi. : 50 % will have TM rupture
  - Lung injury:
    - if << 30 psi :
      - unlikely
    - if P > 75 psi. :
      - very likely
      - 75% of victims will have lung injury

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Notes: Blast and TBI

Okie S. Traumatic brain injury in the war zone. N Engl J Med 2005;352:2043-2047.

Mayorga MA. The pathology of primary blast overpressure injury. Toxicology 1997;121:17-28.

CDC web pages:

- Blast Lung Injury: What Clinicians Need to Know.
  http://www.bt.cdc.gov/masscasualties/blastlunginjury.asp
- See also:

  Explosions and Blast Injuries: A Primer for Clinicians http://www.bt.cdc.gov/masscasualties/explosions.asp

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Summary

- Acute Mountain Sickness : a “headache plus” that can develop into severe HACE.
- HAPE, which may or may not be preceded by AMS, results from the HVR (hypoxic ventilatory response
- HAPE has the highest lethality
- HAPE is a non-cardiogenic pulmonary edema which may respond more to O2, CPAP, and beta agents than to a standard NTG-lasix approach-but NOT to steroids
- Lightning injury: Prolonged apnea and the need for rescue-vent. assistance. Reverse triage. And tell-tale signs of injury.
- Blast injuries of hollow organ (ear / lung / GI / CNS); and what to use as indicator of psi. and of possible lung burst

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