SCUBA DIVING INJURIES AND TREATMENT

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Objectives

- Understand the following conditions as they relate to scuba diving
  - Barotrauma
  - Hypothermia
  - Drowning
  - Pulmonary Over inflation Syndrome
  - Decompression illness
  - Hyperbaric Oxygen
BAROTRAUMA

- Injury caused by changes in pressure
- “Ingredients”
  - rigid walls
  - gas filled space
  - enclosed space
  - ambient pressure change
BAROTRAUMA

- SQUEEZE
  - barotrauma of descent
  - damage from relative vacuum
BAROTRAUMA

- REVERSE SQUEEZE
  - barotrauma of ascent
  - damage from expanding gases
BAROTRAUMA

- EXTERNAL EAR
  - Predisposing Factors
    - obstruction of the external canal by wax
    - tight wet suit hood
    - ear plugs
    - otitis externa
BAROTRAUMA

- MIDDLE EAR “MOST COMMON”
  - **Etiology**: blocked Eustachian tube
  - **Predisposing Factors**
    - infections (URI)
    - allergies (Hay Fever)
    - anatomic variations
    - inability to equalize pressure
BAROTRAUMA

- MIDDLE EAR “MOST COMMON”
  - Clinical Manifestations:
    - mild: injected TM
    - moderate: intratympanic hemorrhage
    - severe: hemorrhage behind TM with or w/o perforation
BAROTRAUMA

- MIDDLE EAR "MOST COMMON"
  - Treatment
    - no diving until re-evaluated
    - decongestants i.e. Sudafed, Afrin
BAROTRAUMA

- INNER EAR
  - implosive or explosive injury
  - round window rupture
  - oval window rupture
  - intracochlear membrane rupture
BAROTRAUMA

- INNER EAR
  - Clinical Manifestations
    - fullness of middle ear on descent
    - forceful Valsalva
    - audible “pop”
    - sudden onset of roaring tinnitus
    - sudden onset of vertigo
    - persistent increasing vertigo
    - persistent neurosensory hearing loss
    - visual findings
BAROTRAUMA

- INNER EAR
  - **Treatment**
    - R/O AGE or DCS
    - strict bed rest
    - avoid straining (stool softeners, antiemetics, antivertigo medications, sedation)
    - **ENT REFERRAL**: standard of care is surgery within 24 hours
BAROTRAUMA

- SINUS
  - obstructed sinus ostium (infection, allergy, anatomy)
  - NO diving
  - decongestants
  - observe for infection
BAROTRAUMA

- **TOOTH**
  - Prevention is the key!
  - **Predisposing Factors**
    - dental disease
    - inadequate dental restorations
    - recent dental work
BAROTRAUMA

- FACE MASK SQUEEZE
  - failure to clear face mask on descent
  - subconjunctival hemorrhages
  - no treatment necessary
BAROTRAUMA

- ABDOMINAL SQUEEZE
  - usually from panic ascent
  - antacid use
  - overbreathing and air swallowing
  - symptoms abate with descent
BAROTRAUMA

- PULMONARY
  - deep breath-hold dive to a depth at which lung volume is reduced below residual volume
  - intra alveolar hemorrhage, exudate
  - chest pain
  - progressive dyspnea
  - progressive frothy, bloody sputum
  - R/O AGE and DCS
TOXIC MARINE LIFE

- **TREATMENT SUMMARY**
  - First aid only: predators, shellfish, octopii
  - Antivenin: sea snakes, stonefish, box jellyfish
  - Vinegar: jellyfish, corals, sea anemone
  - Hot soaks: vertebrate stings, starfish, sea urchins
  - Emesis or gastric lavage: pufferfish, paralytic shellfish poisoning, *Ciguatera* (REEF FISH), *Scombroid* (consider antihistamine)
  - Steroid ointments: sponges
HYPOTHERMIA

- IMMERSION
  - Core body temperature of 95°F (35°C) or below
  - Water temp 91°F (33°C) is EUTHERMIC
HYPOTHERMIA

- **Heat Losses In Diving**
  - immersion: thermal conductance of water is 25 times that of air (moving water up to 200)
  - respiratory losses: diving gases are dehumidified
  - physical activity in water < 77F (25C) is CRITICAL TEMP
HYPOTHERMIA

- Factors Limiting Heat Production
  - fatigue
  - malnutrition
  - dehydration
  - metabolic disease
  - cardiac disease
  - low fitness
HYPOTHERMIA

- RESPIRATORY SYSTEM
  - 1st 1-2 min, ventilation incr. up to 5 times normal due to incr. tidal volume and resp rate
  - initial gasp, risk of aspiration and risk of drowning
  - hyperventilation incr. CO2 off-gassing light headedness, confusion, muscle tetany
HYPOTHERMIA

- CARDIOVASCULAR SYSTEM
  - peripheral vasoconstriction, muscle and skin flow decr. shift to central vasculature leading to warm central “core” surrounded by a cold “shell” of musc/skin tissue
  - BP incr. from incr. fluid volume
  - dysrhythmias: V fib rare below 32C core temp
HYPOTHERMIA

- CARDIOVASCULAR SYSTEM
  - diuresis from incr. vol from peripheral vascular resistance and “hydrostatic squeeze” of tissue below water’s surface can incr. urine production by 350%
HYPOTHERMIA

- CENTRAL NERVOUS SYSTEM
  - progressive depressed mental status below core temp of 33°C
  - loss of consciousness at core 27-30°C
  - hallucinations, impaired judgement: remove floatation devices, attempt to swim to shore, remove clothes
  - panic, alarm, fear, loss of “will to live” often lead to fatal outcome
HYPOTHERMIA

- MUSCULOSKELETAL SYSTEM
  - Vasoconstriction leads to lost limb strength, coordination, reaction time affecting ability to swim, stay afloat, get into lifeboat, etc
  - Lost fine motor skills leads to inability to use signaling devices (pyrotechnics, strobe light, mirror, radio, etc)
HYPOTHERMIA

- TREATMENT
  - remove wet clothing; protect from wind; get out of cool air
  - passive external rewarming: dry clothes, warm environment, blankets
  - active rewarming: warm bath (up to 110°F), observe in sauna (engine room)
  - handle gently to avoid arrhythmias
HYPOTHERMIA

- **TREATMENT**
  - rehydration: oral for mild, otherwise IVs; avoid alcohol or caffeine
  - use IV D5W, D5NS, NS
  - DO NOT USE LACTATED RINGERS; a cold liver cannot process this solution
  - minimize physical activity; DO NOT massage cold limbs (increases afterdrop)
HYPOTHERMIA

- AFTER DROP
  - continued core cooling immediately following removal of victim or during early stages of rewarming
  - heat continued to conduct from warm core to cold periphery
  - venous return of cooler blood from periphery (especially with vasodilatation)
NEAR DROWNING

- **Drowning**: suffocation from submersion in a liquid medium
- **Wet drowning**: implies aspiration (80-90% of drowning)
- **Dry drowning**: asphyxia secondary to laryngospasm in the absence of aspiration (10-20%)
NEAR DROWNING

- DROWNING SEQUENCE
  - violent struggle, panic, hyperventilation
  - calmness apnea
  - fluid swallowing with subsequent vomiting
  - aspiration
  - convulsion
  - coma
  - death
NEAR DROWNING

- PROBLEMS
  - TISSUE HYPOXIA
  - LACTIC ACIDOSIS
  - ACUTE RENAL FAILURE
  - Survivors do not aspirate large volumes of water
NEAR DROWNING

TREATMENT

- always hospitalize
- treat latent pulmonary edema (ARDS), aspiration pneumonia, neurological sequelae (10-30% of victims will sustain some degree of permanent neurological damage)
- prophylactic steroids or antibiotics are not recommended
PULMONARY OVERINFLATION SYNDROMES (POIS)

- MEDIASTINAL EMPHYSEMA
  - results when gas expansion forces gas into the loose mediastinal tissues in the middle of the chest
  - symptoms: chest pain behind the sternum (tightness, burning)
  - no other symptoms
  - symptoms generally do not get worse
  - no treatment is necessary
PULMONARY OVERINFLATION SYNDROMES (POIS)

- **SUBCUTANEOUS EMPHYSEMA**
  - results from expansion of gas which has leaked from the mediastinum into the subcutaneous tissues of the neck
  - symptoms: feels like “Rice Krispies” under the skin
  - there may be a voice change due to pressure on the larynx
  - no treatment is necessary
PULMONARY OVERINFLATION SYNDROMES (POIS)

- PNEUMOTHORAX
  - accumulation of gas within the pleural space
  - symptoms: chest pain, more likely lateral or apical; cough; SOB
  - treatment: 100% O2 and chest tube prn
PULMONARY OVERINFLATION SYNDROMES (POIS)

- ARTERIAL GAS EMBOLISM
- BAD, VERY BAD
- *THE MOST SERIOUS POTENTIAL COMPLICATION OF DIVING CAUSED BY EXCESS AIR PRESSURE IN THE CHEST!!*
- *BOYLE’S LAW*
- alveolar rupture with injection of air into capillary so that a bolus (bubble) of air enters pulmonary veins and left ventricle
PULMONARY OVERINFLATION SYNDROMES (POIS)

- **ARTERIAL GAS EMBOLISM**
  - the brain is the most significant site of embolus
  - symptoms: **ANY** type of neurologic sign or symptom (unconsciousness, weakness, paralysis, paraesthesia, etc) within 10 min of surfacing
  - AGEs do not go to the spine (think DCS)
  - tx: **IMMEDIATE RECOMPRESSION**
ARTERIAL GAS EMBOLUS
DECOMPRESSION ILLNESS

- Remember Henry’s Law
- on-gassing/off gassing
- Oxygen is absorbed rapidly by the tissues but Nitrogen is not
- Nitrogen is 5x more soluble in fat
- Venous system operates at a lower pressure so bubbles form in the veins
DECOMPRESSION ILLNESS

- TISSUE HYPOXIA
- Mechanical effects
- Biochemical effects
- Recompression will reverse the mechanical effects and prevent the late biochemical effects
DECOMPRESSION ILLNESS

• RISK FACTORS
  - Advanced age
  - Female
  - Obesity
  - Low water temp
  - Poor physical fitness\ excessive phys activ.
  - Repetitive dives
DECOMPRESSION ILLNESS

- TYPE I
- “minor DCI”, not lethal
- 30% progress to Type II
DCI TYPE I

- **LIMB PAIN** - 70%, dull ache near the joint unable to pinpoint specific location
- Back or trunk pain not clearly related to the hip or shoulder, treat as Type II
- **LYMPHATIC** - 20%, painful swollen nodes, recompression helps with pain but not swelling
DCI TYPE I

- **CUTANEOUS BENDS** - 10%, itching (not DCI), Cutis Marmorata - red rash with central cyanosis
- Complete relief during recompression treatment
DCI TYPE II

- BAD, VERY BAD
DCI TYPE II

- Symptoms commonly appear 10-30 min after surfacing
- malaise and fatigue very common
- CNS involvement is usually to the spinal cord
- paresthesias and numbness most common
SPINAL CORD DCI

- Most common
- Often preceded by pain
- Para/Quadraplegia
- Bladder/bowel incontinence
- Weakness
- Paresthesias
- Radicular pain
HYPERBARIC OXYGEN

- 2.8 ATA bubble volume is reduced by almost two thirds
- oxygen replaces the inert gas in the bubble, which is then rapidly metabolized by the tissues
- prevents the formation of new bubbles
- antibacterial effects
APPROVED INDICATIONS

- CARBON MONOXIDE, CYANIDE AND SULFIDE INTOXICATION
- DECOMPRESSION ILLNESS
- ARTERIAL GAS EMBOLUS
- GAS GANGRENE
- BACTERIAL OSTEOMYELITIS
- OSTEONECROSIS
APPROVED INDICATIONS

- TRAUMATIC ISCHEMIA
- NECROTIZING SOFT TISSUE INFECTION
- ACUTE BLOOD LOSS ANEMIA
- THERMAL BURNS
- COMPROMISING SKIN GRAFTS
- CHRONIC WOUNDS
- RETINAL ARTERY OCCLUSION
HYPERBARIC OXYGEN

- COMPLICATIONS INCLUDE OXYGEN TOXICITY AND THOSE COMMON TO SCUBA DIVING
ABSOLUTE CONTRAINDICATIONS

- UNTREATED PNEUMOTHORAX
- DOXORUBICIN THERAPY – Cardo Tox
- CIS-PLATINUM THERAPY – Wound
- DISULFIRAM THERAPY – O₂ Tox
- BLEOMYCIN – interstitial pneumonitis
- SULFAMYLON – impaired wound healing
Relative Contraindications

- Asthma
- Claustrophobia
- COPD
- E.T. dysfunction
- High fever
- Pacemaker
- Pregnancy
- URI
- Seizures
HBO TREATMENT

- mono vs multiplace chamber
- starting depth usually 60ft
- patient breaths 100% oxygen with scheduled air breaks
- DCI TYPE I -- TABLE 5
- DCI TYPE II/AGE -- TABLE 6
DISCOURAGE DIVING IF:

- ASTHMA / COPD
- SPONTANEOUS PNEUMOTHORAX
- CYSTIC LUNG LESIONS
- CAD - TREADMILL TO 13 METS
- VALVULAR DISEASE (except MVP)
- ARRHYTHMIAS
- EPILEPSY
- DIABETES
DRUGS AND DIVING

- NONE ABSOLUTELY SAFE
- RELATIVELY SAFE:
  - Decongestants
  - Tylenol/NSAIDS
  - Topical meds
  - Vitamins
  - BCP’s
FLYING AFTER DIVING

- **WAIT 12 HOURS AFTER A SINGLE NO DECOMPRESSION DIVE**
- **WAIT 18-24H FOR MULTIPLE DIVES OR DIVES REQUIRING DECOMPRESSION**
- **IF FLYING AN AGE OR DCS PATIENT, RECOMMEND LOW, LESS THAN 1000 FT AND FAST (HELO PREFERRED)**
THANK YOU