Marine Envenomations and Drownings

BRAD JOHNSON
Goals and Objectives

- What is a venom?
- Antivenom
- Mechanism of envenomations
- Marine envenomations
  - Where are they found?
  - Symptoms
  - Treatment
- Drowning
  - Pathophysiology
  - Treatment
  - Prognosis
Venom vs Poison

**Venom**
- Typically contain an apparatus to deliver toxin
- Can be released in varying amounts depending on sense of threat by organism
- Heat and acid labile
- Typically vasoactive amines, proteolytic enzymes.

**Poison**
- Typically produced in skin, muscle, blood, or organs
- Not released
- Heat and acid stable
- Typically consist of metabolic byproducts
Anti venoms

- Typically indicated in box-jellyfish, stone fish or certain sea snake envenomations
- Raised in horses or sheep, may be antigenic in humans
- Typically recommend skin testing prior to administration if clinical situation permits
  - Typically wheal and erythema occurs within 15-30 minutes
  - Positive test requires pre treatment (Benadryl 50-100mg IV) and dilution of antivenom
Common marine venom apparatus

- **Cnidocysts**
  - Venom delivery apparatus used by Portuguese Man of War (Hydrozoan), Corals, Sea Anemones, True Jellyfish
  - Cnidocytes, mature living cells that encapsulate cnidocysts, in which the stinging apparatus is found
  - Cytes found in specialized tentacle epithelial cells (battery cells)
  - Triggered to be released in spring like a harpoon mechanism, to release a hollow tubule with venom in a membrane surrounded by hollow barbs
Coral

- Common with snorkelers, surfers and scuba divers that touch, step on or fall onto
- Use of nematocysts, cnidocyst
- Sx: Mildly toxic, local pain and erythema, prone to secondary infection
  - Intense and painful pruritus within seconds, 5-30 min urticarial wheals develop an peak within 60 minutes. If untreated flatten over 14-24hrs and resolves within 3-7 days. At times leaving area of hypopigmentation
- Tx: Rinse with sea water, then soak in vinegar or isopropyl alcohol until pain is relieved. May use systemic steroids if rash is severe
Coral Rash
Sponges

- Envenomations typically occur on the hands or feet, when divers touch them without gloves or flippers
- Attach to sea floor or coral beds
- Contain skeletons of silicon dioxide and calcium carbonate which contain crinotoxins
- Sx: Pruritic or Irritant dermatitis; Hawaiian or West Indian Fire Sponge, Poison Bun Sponge
  - Similar to contact dermatitis from plants, itching, burning, may progress to joint swelling, tissues edema vesiculation if small pieces are retained in skin
  - Reaction occurs within minutes to hours, and typically lasts 3-7 days if untreated
  - With irritant dermatitis develop sloughing of the skin
- Tx: Gently dry skin, remove spicules with adhesive tape, rubber cement, or facial peel. Acetic acid soak for 10-30 min 3-4 x a day, isopropyl alcohol acceptable. Followed by steroid application, systemic if severe skin sloughing occurs. Clostridium tetani culture from many sea sponges, ensure tetanus ppx
Sponge Rash
Sea anemone

- Burrow into sand mud
  - Very colorful and flowerlike
  - Often stung and rubbing without gloves
- Contain stalked, finger like projections with stinging apparatus, cnidocyst
- Cytolytic and hemolytic toxins, neurotoxins, cardiotoxins
- Sx: Dermatitis, circular and painful urticarial lesions, similar to bee sting. Edema, paresthesia, erythema. Vesiculation with local hemorrhage and necrosis can occur when severe. Mild resolve within 2 days. Severe/systemic can lead to necrosis and CV collapse, very rare
- Tx: Rinse with sea water, if fresh water use 45 C, then soak in vinegar. Use topical antihistamines, analgesia as needed
Sea Anemone Rash
Sea Urchin

- Shallow water greatest risk, deep water most dangerous uncontrolled ascent leading to barotrauma and drowning. Stepped on, brushed upon, handling, typically at night diving as they are nocturnal. If move hand slowly towards spine, they align and multiple punctures occur.

- Have long sharp spines made of calcium carbonate, may break off into skin.

- Sx: Incapacitating pain, may last up to 24hrs. Prolonged bleeding, soft tissue swelling (granuloma formation if spines retained), tattooing of skin from dye of spine. Usually absence of spine leads to resolution of discoloration within 48hrs. If enters joint causes severe synovitis.
  - Systemic symptoms when multiple or deep penetrating, n/v, resp distress, paralysis, hypotension, delirium due to intense pain.

- Tx: Supportive, hot water may help to disable the toxin, remove foreign body, control bleeding, analgesia.
  - US or Xray useful for retained spines.
Sea Urchin Rash
Star Fish

- Found on ocean floors
- Thorny spines of calcium carbonate crystals
  - Release saponins and histamine like compounds, hemolytic, anticoagulants, hepatotoxic
- Sx: Immediate pain and copious bleeding with mild edema, self limited 30min to 3hrs. Multiple puncture wounds may lead to paresthesia, nausea, vomit, LAD and paralysis. Tenosynovitis common complication
- Tx: Analgesia, irrigation and removal. Calamine and local steroids of dermatitis
Star Fish Envenomation
Cnidaria (Jellyfish)

- US coast, Caribbean, deadliest of which being found in Australian coast.
- Use nematocysts in tentacles to sting
- Venom is antigenic and can cause dermatonecrosis, hemolysis, neuratoxility and cardio toxicity
  - Severity depends on number of nematocysts discharged, type of jellyfish and antigenic response of the patient
  - May result in immediate allergic, immediate toxic, or delayed allergic responses, depending on the degree of envenomation and the patient's immunologic response.
  - The most common presentation is a painful papular-urticarial eruption at the site of contact, often in a linear, streak like distribution from the long tentacles. Lesions may last for minutes to hours, with further progression to vesicular, hemorrhagic, or necrotizing lesions. Pain and paresthesia lasting 2-3 days.
- Tentacle removal can be done with skin scrapings (apply shaving cream or baking soda slurry and shave off), forceps or applying sticky tape (caution not to directly touch skin) and inactivation of nematocyst with vinegar or acetic acid for at least 30 min or until pain subsides (inactivate prior to removing)
  - Hot or cold water acceptable for pain relief
  - Local wound care, antihistamines, topical anesthetics, steroids?
  - Abx unnecessary
  - Avoid urine or rubbing with sand
  - Meat tenderizer ineffective
- Tentacle continue to function after being separated jellyfish and can sting even if jellyfish is dead
Box Jellyfish

- Found near Australian coast, Indonesia, Malaysia
- Contains enough venom to kill three adults
- Deadliest Jellyfish
- Irukandji Syndrome: occurs when small amount of venom is injected
  - Discovered by Jack Barnes, who intentionally stung himself to prove that jellyfish were cause of symptoms
  - Sting is typically initially small and painless, similar to mosquito bite
  - Develop strong catecholamine surge, leading to HA, ABD pain, N/V, sweating, HTN, hypotension, pulmonary edema and severe sense of impending doom: at times patient will beg for death to kill them
  - Symptoms typically resolve within 4-30 hrs but can last for weeks
  - Tx: Benzodiazepines, Magnesium Sulfate to prevent arrhythmias, Phentolamine for alpha adrenergic blockade. Bronchodilator may be helpful if develop wheezing due to bronchospasms

- Excruciating pain leads to struggling and rapid progression (2-3 min) of worsening symptoms including hypotension, muscle spasm, paralysis, leading to drowning or cardiac arrest can occur within minutes
  - Typically rapidly develop severe blister with surrounding necrosis
  - Mortality: 15-20%, most common after contact with tentacles 6-7m, however 10cm can deliver fatal dose

- Tx: if no antivenom, apply constriction bandage proximal to sting to impede lymphatic and venous return, loosen for 10 sec then repeat after 1 hr. Administer IV may repeat every 2-4 hrs until symptoms stop worsening. Administer with steroids to decrease inflammation. IV verapamil may help cardiac effects, but use with caution with hypotension
Box Jellyfish Sting
Portuguese Man of War

- Tropical and semitropical Atlantic ocean, off coast of Florida, Gulf of Mexico, Australian coast
- Release active tentacles after coming in contact
  - Tentacles are nearly transparent
  - May wash up onto beaches and remain active for months
- Symptoms: severe pain with whip-like, red welts on the skin lasting two or three days after the initial sting. Pain main subside after a few hours. If the venom travel to the lymph nodes depending on the amount of venom, a more intense pain. A sting may lead anaphylaxis which can lead to death, rare.
Portuguese Man of War Sting
Cone Fish (Conidae)

- Warm regions of Indian and Pacific oceans
- Stings common in shell collectors, drop if snail begins to protrude
- Very slow moving but attack fast prey, which has led to them developing the fastest attack in animal kingdom
- Barb attached to harpoon like probe discharged into skin
- Venom: Conotoxin, acetylcholine blockade paralytic and lethal oligopeptide toxin target ion channels
- Symptoms: initial local numbness and ischemia leading to involvement of entire limb. Then systemic sx leads to nausea, paralysis, coma, DIC, resp failure.
- Tx: immersion in warm water, compress bandage, immobilization. NO ANTIVENIN. Edrophonium for paralysis, Tensilon Test inject small amount test muscle strength then full dose 2 then 8mg CV and RESP SUPPORT. May take several weeks to resolve
Blue Ringed Octopus

- Indo-Pacific, Papau New Guinea and Australia, near rocky ocean floor
- Envenomations typically occur when picked up
- Tetrodotoxin in salivary glands delivered by bite, lasts 4-10hrs
  - Blocks Na channels -> flaccid paralysis and resp failure
- Symptoms: Occur within 10-20min. Minor ache with slight pulsating stinging sensation which leads to involve entire limb after 5-10 min
  - Systemic symptoms lead to n/v, miosis, diabetes insipidus, depressed cortical activity and paralysis. Can last 4-10 hrs
- Tx: Supportive, no antivenin, some success with edrophonium, neostigmine, 4-aminopyridine
Sea Snake Envenomation

- Indian and Pacific oceans from the East Coast of Africa to the West Coast of the United States and Central and South America
- Close to land in coral reefs or along islands
- Typically occur in fisherman when snakes are in nets or
- Contain hollow fangs, which easily dislodge leading to minimal amount of venom injected
- Toxin is neurotoxin which blocks transmission at NMJ, acetylcholine receptor blockade
- Sx: Typically painless bite with limited local tissue toxicity
  - Quiescent period may last several hours leads to 2 major syndromes
    - Neurotoxic Flaccid paralysis
      - Ptosis and bulbar cranial nerve dysfn leading to general paralysis and resp arrest
    - Rhabdomyolysis
      - Muscle pain, tenderness, weakness th myoglobinuria, hyperkalemia and ARF
- Tx: Keep calm. Immobilize limb, apply constrictive bandage to decrease venous and lymphatic return, release every 10min for 90seconds. Respiratory support as respiratory failure often occurs. Monitor urine output and renal fxn due to risk of rhabdo, ARF may require temporary dialysis.
  - All cases of envenomations warrant Antivenom
  - Consult medical toxicologist

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Scorpion/Lion Fish

- Tropical and Temperate Oceans
- Often kept as pets
- 10 to 15 dorsal spines, as well as two pelvic and three anal spines associated with venom glands
- Toxin hyaluronidase, degrades connective tissue leading to poor wound healing
- Symptoms: Immediate, intense pain which radiates proximally, with erythema and surrounding edema. Peaks in 30-90 minutes if untreated. Typically lasts 4-6 hrs. Pain may be severe enough to cause delirium
- Tx: Removal of barb, irrigate with warm water. Treat pain
Stone Fish

- Coastal waters of Indo-Pacific (Australia, Indonesia, India)
- Bottom dwellers in shallow water, envenomation typically occur when stepped on
- Powerful spines with highly developed venom glands, potentially fatal
- Toxin is myotoxic, neurotoxic, with cardiotoxic components
- Sx: Immediate incapacitating pain, spreads to involve entire limb and lymph nodes. Resolves over weeks. Edema, vesicle formation with skin sloughing at site of sting. Systemic symptoms included weakness, dyspnea secondary to pulmonary edema and hypotension. Death is rare but typically will occur within 6-8hrs.
- Tx: Analgesia, immobilize, wound debridement, hot water immersion. CV and Resp support. Antivenin available, typically indicated when analgesia not achieved with warm water immersion and parenteral analgesia
  - If pt stable, recommend skin testing prior to administration. 1 vial IV diluted with NS over 15 minutes
Cat Fish

- Bottom dwelling scavengers, worldwide
- Stings common in fishermen
- Have single dorsal and two pectoral fin spines. Spines surrounded by sheath containing venom glands
- Toxin is hemolytic, and dermatonecrotic
- Sx: instantaneous stinging, throbbing with proximal radiation. Pain 1-24hrs. Area quickly becomes ischemic with central pallor followed by cyanosis prior to erythema and edema. Secondary infection is common in not adequately irrigated
- Tx: Immersion in warm water. Removal of spine and irrigate. Consider Radiographs helpful to r/o retained spines.
  - Popular but unstudied remedy involves rubbing wound on belly of catfish.
  - Abx for deep wounds in hands and feet. E. Tarda common bacteria, cover with Amp, Cephalexin, or Bactrim. Doxy if in salt water to cover Vibrio
Sting Ray

- Bottom dwelling, temperate and semitropical zones, injury late summer and early fall when burrow in shallow sand.
- Barbed stingers and 2 venom containing grooves, whip like tails with furrowed, serrated spine. When agitated flings tail upward.
  - Venom contains high doses of serotonin. Also has vasoconstrictive properties which can lead to local cyanosis and necrosis with diminished wound healing.
- Typically cause traumatic penetrating trauma.
- Sx: Intense pain, syncope, n/v, diarrhea, diaphoresis, muscle cramps, seizures, hypotension.
- Tx: Dependent on length and depth of injury. Immerse in hot water for 30-90 min or until pain subsides, then remove barb. Delayed closure of large wounds. Plan xrays helpful.
  - Treat chest and abd wall penetration as penetrating trauma, typically warrant CT or ex lap.
  - Recover 24-48hrs.
- Prevention: shuffle feet when walking or wading at shallow depths.
Diagnosis of Envenomations

- History of encounter with animal, typically with surfing, scuba diving or cleaning aquarium
- Sudden onset of pain
- Single or multiple puncture wounds (fish, sting ray, coral, sea urchin) (jellyfish or sea anemone, lack punctures.)
Drowning

>500,000 worldwide

Leading cause of injury death in ages <15

Two groups: Teenagers and toddlers

- Teenagers (15-24): 80% males
  - Alcohol is a factor in 60%
- Toddlers: 59% occur in bathtubs
  - 56% associated with child abuse
Important Terms

- Wet drowning: aspiration of water occurs prior to laryngospasm (80-90%)
  - With 1-3mL/kg integrity of pulmonary surfactant is destroyed > alveolar collapse, atelectasis, pulmonary edema, shunting and v/q mismatch

- Dry drowning: laryngospasm occurs without aspiration (10-20%)

- Immersion Syndrome: sudden death after sudden contact with water > 5 C from body temperature, typically due to cardiac dysrhythmia

- Mammalian Diving Reflex: Parasympathetic activation after submersion into cold water leading to decreased metabolic demand and shunting of blood from periphery to core
  - Strongest in infants (lower ratio of body mass and surface area) and decreases with age,
  - In adults, concurrent activation of sympathetic and parasympathetic, blunting response
Previously thought that changes in osmolarity due to ingestion caused death

- Salt water: hypertonic→pulling fluid into alveoli→decreased blood volume and increased osmolarity
- Fresh water: hypotonic→fluid diffuse into blood→increased blood volume and decreased osmolarity

Would require 22mL/kg of water ingestion to cause changes
- Typically only 3-4mL/kg are ingested
What happens

- First: unexpected and prolonged submersion leading to panic and struggle with increased sympathetic response
- Second: Consumption of energy and O2->fatigue and air hunger
- Eventually reflexive inspiration overrides breath holding causing aspiration and swallowing of water
- Leading to laryngospasm and glottis closure
- Worsening hypoxemia and syncope
- Death caused by hypoxia with metabolic and respiratory acidosis leading to cardiovascular arrest and CNS damage.
What to do
What to do

- **PREHOSPITAL TREATMENT……MOST IMPORTANT ASPECT OF CARE**
  - ABC, as fast as possible to reverse hypoxia and anoxic brain injury
  - If patient not breathing BVM in field, with hyperventilation with 100% O2, mouth to mouth assisted ventilation even prior to extrication from water
  - CPR

- **ED Management**
  - Establish definitive airway, ET intubation vs BiPap to decrease pulmonary edema
  - Active and passive rewarming.
  - Accucheck and Narcan?
  - C-Spine injury in less than 0.5%, be aware of hx of diving, motorized accident or associated trauma. Routine immobilization and CT scan unnecessary
  - Continue resuscitation until T 32-35 C
Beyond Resuscitation

- **Antibiotics**
  - Only in cases of clinical infection
  - Unless water is grossly contaminated (sewage)
    - Cover for Aeromonas, Pseudomonas, and Proteus
      - Cefepime and Cipro
- **Corticosteroids for ARDS and cerebral edema**
  - Unproven and remain controversial
- **Barbiturate coma with neuromuscular blockade to reduce metabolic demand**
  - Not been shown to improve mortality
- **Therapeutic Hypothermia**
  - Many case reports showing benefit,
  - Rewarm to 34 C
Are they going to make it?

- GCS <5
- Submersion >5 minutes
- Delay in CPR
- pH <7.0
- Water temp >10 C, 77 F
- Asystole on arrival

**Szpilman Classification of Near Drowning and Drowning**

- Grade 1 Normal Pulmonary Auscultation +/- cough Mortality Rate 0
- Grade 2 Rales or crackles in some fields Mortality Rate 0.6
- Grade 3 Crackles in all fields without hypotension Mortality Rate 5.2
- Grade 4 Crackles in all fields with hypotension Mortality Rate 19.4
- Grade 5 Resp Arrest without cardiac arrest Mortality Rate 44
- Grade 6 Cardiopulmonary Arrest Mortality Rate 93
In summary: Envenomations

**Treatment of Vertebrate Envenomations**

- Deactivate toxin prior to manipulation
  - If using fresh water use approx. 45 °C
  - Soak in acetic acid/vinegar
- Remove tentacles with tape or by shaving skin
  - Irrigation with salt water can help remove nematocysts
- Adequate analgesia
- Apply topical antihistamines or corticosteroids for itching
- Antivenom for Box Jellyfish
- CV and Resp support for Cone fish, and Blue ringed Octopus envenomations

**Treatment of Vertebrate Envenomations**

- Warm water immersion 40-45 °C for up to 90 minutes
- Opioids and nsaids
  - If pain persist local or regional blocks
- Copious irrigation and cleansing
- Remove foreign bodies.
- X rays or US useful
- Tetanus ppx
- Wounds should be left open! Or undergo delayed primary closure
- Abx not recommended routinely
  - Superficial wounds may benefit from bacitracin
  - Deep puncture wounds (stingray), abx against Vibrio and skin flora
    - Doxycycline-Vibrio
    - 1st gen cephalosporin-Cephalexin, Cefazolin
    - Clinda or levo for MRSA
- Antivenom for sea snake and stone fish
In summary: Drowning

- In field treatment most important aspect
  - Require rapid reversal of hypoxia by assisted breathing
- Upon arrival to ED establish definitive airway
- Warm patient and continue resuscitation until core temp 32-35 C
- Consider therapeutic hypothermia 34 C after ROSC
- Poor Prognostic Indicators
  - GCS <5, Submersion >5 minutes, Delay in CPR, pH <7.0, Water temp >10 C, 77 F, Asystole on arrival


Auerbach P. Wilderness Medicine ed. 6, Ch 80 Envenomations by Aquatic Invertebrates