Water Envenomations and Stings

Erika Reese, MD, CPT, USA, FBCH and Patrick Depenbrock, MD, MAJ, USA, FBCH

Abstract
Marine envenomations are an important part of sports medicine. Marine sport is practiced widely, and many aquatic envenomations require quick recognition and timely action to ensure the safety and recovery of victims. Even a basic knowledge of treatments of various envenomations could help clinicians be more effective in acute treatment. The purpose of this article is to review known literature and expand on recent progress in the field of aquatic envenomations.

Introduction

Human contact with marine wildlife via sport, leisure, or occupation is an integral part of daily life to many persons around the world. Surfers, swimmers, boaters, divers, and sport fishermen are all subject to contact with marine wildlife. This contact frequently results in envenomation injury, although the severity is usually mild. There are various species of marine wildlife that are capable of causing injury through envenomation. These include sponges, jellyfish, vertebrate fish species, coral, stingrays, and sea snakes. Knowledge of signs, symptoms, and immediate treatments is vital to preventing significant, and sometimes fatal, injury.

Phylum Porifera

Better known as sponges, these organisms are composed of approximately 5,000 species. Envenomation usually results from a combination of surface toxins as well as cohabitating hydrozoans, mollusks, and coelenterates (2,16). Sponges have internal collagenous skeletons made of spongin and secrete toxins such as crinotoxin, which is known to irritate the skin of swimmers and divers (2).

Two different reactions to sponge envenomation are common. The first syndrome, dermatitis characterized by itching/burning, vesiculation, and local joint swelling, occurs within minutes to hours after contact. Mild reactions typically resolve in 3 to 7 d without treatment. Reactions that are more sever include fever, chills, malaise, dizziness, nausea, muscle cramps, and formication (tactile sensation of insects crawling on the skin) (2). Initial treatment includes removing spicules with adhesive tape, dilute acetic acid soaks to the envenomation site, and the use of topical or oral steroids (16). As with most envenomations, documentation of tetanus immunization status is important. Use of prophylactic antibiotics targeting common skin flora is controversial; however monitoring for secondary skin infection during the first week is recommended (2).

A delayed onset reaction of erythema multiforme/dyshidrotic eczema and anaphylaxis have been observed in some individuals 1 to 2 wk after envenomation. This syndrome occurs much less frequently than the common envenomation reaction listed previously, and it is likely secondary to small calcium carbonate/silica spicules, which are deposited upon human contact with sponges. Treatment includes steroids and epinephrine in the event of anaphylaxis. Unfortunately there is no way to predict or to prevent these delayed onset reactions (2)

Phylum Cnidaria (Jellyfish)

Cnidaria, commonly referred to as jellyfish, consists of about 10,000 species broken into four classes: Hydrozoans, Scyphozoans, Anthozoans, and Cubozoans (2,16). Cnidaria envenomate via the release of nematocysts, which contain multiple enzymes including phospholipase A2 (PLA2), which is thought to work through arachidonic acid (3,14,20). These enzymes, depending on the jellyfish species and size of the victim, can induce mild symptoms ranging from stinging, pruritus, and paresthesias to more serious consequences such as cardiorespiratory collapse, seizure, and in some cases, death (2). Many studies, mostly retrospective analyses and reviews, have investigated the best initial treatment for jellyfish stings. Most treatments target the denaturing of venom enzymes as well as prevention of further nematocyst venom release. Careful removal of cnidaria tentacles from the skin and acetic acid application remain the mainstay of initial management. Recent data suggest that hot water immersion is beneficial not only for preventing further venom release but also for pain modulation (1,8,14,16,27). It is important to ensure that tetanus immunization is up to date and to ensure consideration of antibiotics on a case-by-case basis (2,16). Severe symptoms such as hypotension, bronchospasm, seizures, and hypertension would

Fort Belvoir Community Hospital, 9300 Dewitt Loop, Fort Belvoir, VA

Address for correspondence: Erika Reese MD, CPT, USA, FBCH; Fort Belvoir Community Hospital, 9300 Dewitt Loop, Ft. Belvoir VA 22060; E-mail: erika.s.reese.mil@health.mil.

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require immediate hospitalization and likely intensive care unit (ICU) monitoring (2). A breakdown of each class and general treatment is provided in the succeeding part of this article.

Hydrozoa

Hydrozoa of the phylum cnidaria (Fig. 1) can be divided into *Millepora* and *Physalia*. *Millepora* is characterized most notably by the fire coral. Despite its name, fire coral is not a true coral. This organism sits sessile in the water shallows, protruding a calcium carbonate exoskeleton with gastropores that harbor nematocysts. Human contact with these nematocysts precipitates a cutaneous reaction of burning/itching and erythema that occasionally progresses into a necrotizing or granulomatous reaction (2,16). Systemic symptoms of myalgias, fever, malaise, nausea, and vomiting also may occur (16). Cleansing with seawater, debridement, and acetic acid soaks are the mainstay of treatment (2).

Physalia, also known as the Portuguese man-of-war, is not, despite their appearance, a jellyfish. Instead *Physalia* are made up of colonies of siphonophores, which are hydrozoa (14,26). Although the envenomations of *Physalia* are clinically similar to those of *Millepora*, with cutaneous symptoms of edema, pain, necrosis, and severe systemic symptoms of nausea, vomiting, muscular spasm, and even respiratory distress, treatments may differ depending on the *Physalia*'s oceanic origin (8). *In vitro* studies have shown that acetic acid (vinegar) increases release of venom from nematocysts in multitentacle Australian *Physalia*. Secondary to this finding, many recommend against treatment with acetic acid for *Physalia* envenomation (4,8,12,13,14,26). However Haddad *et al.* (16) noted in a November 2009 review that vinegar was helpful in jellyfish stings in the western Atlantic ocean and Gulf of Mexico. It can be difficult to differentiate between single and multitentacle physalia, and further review on this subject is warranted to gain true clarity for defined recommendations. In addition, some less recent studies have shown Stingose, a Hamilton laboratories product composed of magnesium sulfate and Surfactant, to be more effective than seawater in controlling pain (6,8). In some stings such as those in *Chironex fleckeri*, however, it has not been proven as effective as acetic acid (8,17). Addition of baking soda, papain, and bromelain may limit pain through the prevention of nematocyst rupture (5).

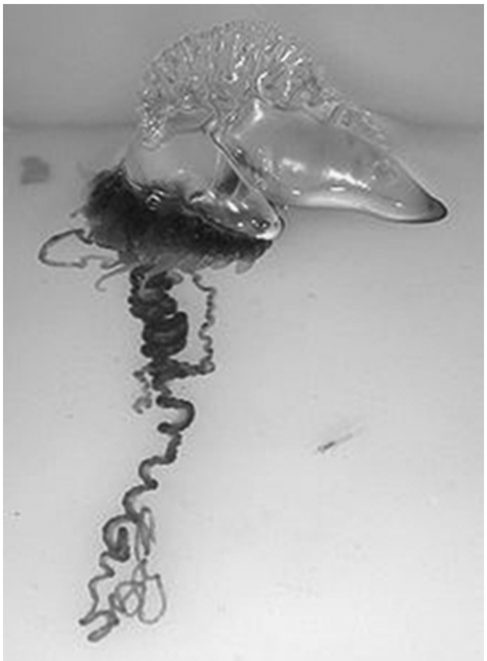

Figure 1: Hydrozoa (Portuguese man-of-war).

Scyphozoans

Scyphozoans, which are true jellyfish, include well-known members such as *Cyanea* (lion's mane jellyfish), *Chrysaora* (Sea nettle), and *Linuche* (2,16). Lion's main jellyfish are large organisms, found in arctic waters, with thousands of tentacles measuring up to 30 m long (1). Sea nettles are found in warmer waters. Contact with these scyphozoan result in cutaneous lesions composed of linear wheals, plaques, and vesicles, but systemic symptoms are usually absent (2,16). The larvae of *Linuche*, commonly found in waters of the Caribbean and Southern US, cause classic "seabather's eruption" when they release a pressure-sensitive toxin upon becoming trapped between skin and clothing. Seabather's eruption is characterized by a self-limiting pruritus that may respond to topical steroids (2,16).

Anthozoans

Soft coral, stony coral, sea pens, and anemones are anthozoans. Although anthozoans secrete mucinous exudate with toxic properties, many harbor nematocysts like their Cnidarea counterparts. Corals have hard calcium bodies that can damage human skin, leaving behind calcium carbonate and other debris that can precipitate infection (16). Toxic exudates secreted by anthozoans cause inflammatory dermatitis with granulomatous changes. These wounds take months to heal, and antibiotics are necessary to prevent secondary infection (2,16).

Cubozoans

C. fleckeri (box jellyfish) (Fig. 2) and *Carukia barnesii* are cubozoans that cause serious systemic illness. *C. fleckeri* has a cubic bell approximately 20 to 30 cm wide and 4 clusters of tentacles measuring up to 3 m long. The tentacles secrete venom with the ability to induce death in 60 s (2,8). Cutaneous reactions include painful purple linear plaques, edema, and erythema. Systemic manifestations include cardiac failure, pulmonary edema, and respiratory distress (2,8,16,24). Treatment includes moving the patient to a secure or stable area, vinegar application, removal of tentacles, ice packs, and hot water immersion (2,8). Recommended hot water immersion techniques include 20 min at 48°C or 2 min at 53°C in order to deactivate the venom (7,14,22,25). The previously mentioned Stingose composed of aluminum sulfate and surfactant was found not as effective as acetic acid for the treatment of *C. fleckeri* envenomations (8,17). Antivenom for *C. fleckeri* has proven effective however (24).

C. barnesii is known for causing Irukandji syndrome, a reaction characterized by pain, headache, backache, joint pain, nausea, vomiting, pulmonary edema, heart failure, and in some cases, intracerebral hemorrhage (8,14,16,24).

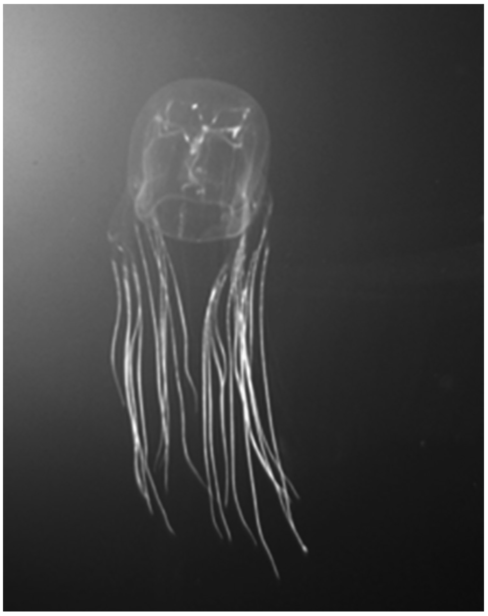

Figure 2: *C. fleckeri* (box jellyfish).

Initial treatment includes cold packs, seawater compresses, hot water immersion, acetic acid, and antibiotic prophylaxis. Several studies conclude that all aqueous treatments should utilize seawater and not fresh water, as the difference in osmotic gradient can cause nematocysts to discharge (8,14,26).

Recent data have found that an intrathecal administration of the medication ziconotide, a synthetic derivative of conotoxin from the cone snail, could counter the effects of *C. barnesii* and Irukandji syndrome. This medication is being studied now for possible intravenous use given that it can be difficult to administer intrathecally if the patient is agitated and in pain. However, currently, only preliminary mathematically extrapolated data exist (10).

Alcohol, methylated spirits, and urine are not shown to work for cnidaria envenomation (27). Pressure-inducing bandages are no longer recommended, as *in vitro* studies have shown increase of nematocyst discharge (8,23). However topical anesthetics such as benzocaine or lidocaine may help with pain relief (27).

For prevention, barriers such as a wetsuit or lycra stinger suit are effective (2). Safe Sea, a type of sting inhibitor that is based on the mucous that coats clown fish, has been tested also in a double-blind randomized controlled trial (5). It was found to prevent 80% of jellyfish stings. This trial, however, was limited by its failure to control for exposure to stings (5).

Phylum Echinodermata

This classification of organisms includes sea lilies, brittle stars, starfish, sea urchins, and sea cucumbers (2). Injuries usually result from stepping on the organisms or directly handling them. Symptoms include localized pain, bleeding, erythema, and edema. One review by Haddad *et al.* (16) noted later sequellae of tenosynovitis, fasciitis, and bursitis. Treatment consists of hot water immersion and pain control. It is important to ensure detailed removal of imbedded spines and debris to prevent chronic infection (16). Retained spines can prolong envenomation effects. In one case study discussed by Lin *et al.* (19) in 2008, a female teenage victim of starfish envenomation with transaminitis was discovered to have multiple starfish spines retained in her skin. Upon surgical removal of the spines, her transaminitis resolved.

Phylum Annelida: Annelid Worms

The bristle worm is an aquatic worm whose chitinous spines inflict localized pain, erythema, and burning on contact with human skin (16). Acetic acid and topical steroids have been used to treat localized symptoms (2). Antibiotics, antihistamines, and medrol dose packs have been used to treat more severe symptoms. An attempt should be made to remove imbedded spines from the skin of the victim. Application of an adhesive tape was an effective method of removing imbedded bristle worm spines from the skin of envenomation victims in a case report in 2010 by Kay *et al.* (18).

Phylum Mollusca: Mollusks

Cone snails have a hollow proboscis with a radicular tooth capable of injecting venom. This venom causes tetany, blocking sodium, potassium, and calcium channels (2,14). Tetany can precipitate respiratory distress and, in some cases, death. In the event of severe or prolonged tetany, patients require intubation and ICU monitoring until the venom effects wear off (14).

Another member of this phylum is the octopus, which injects stinging venom through beaks into its prey. The blue-ringed octopus, a well-known species, secretes tetrodotoxin, which has the ability to cause flaccid paralysis and severe hypotension by blocking sodium channels in the body. Victims with flaccid paralysis require intubation and critical care monitoring until the venom effects dissipate (14).

Vertebrates

Stingrays are a well-known marine vertebrate found throughout the world. They are found commonly in the sea shallows. Waders are injured usually when they step on or near a stingray at the shore's edge. Envenomation occurs when human skin is punctured by the spine protruding from the dorsal surface of the stingray's whip-like tail. A gland at the base of the tail, of which there are four different anatomic variations (gymnurid, myliobatid, dasyatid, and urolophid), secretes the venom (2,14). Venom and mechanical

Figure 3: Stonefish.

Table.
Summary of organisms/clinical symptoms/treatments.

Species	Symptoms	Treatments
Sponges	First syndrome: itching/burning, vesiculation, and local joint swelling → fever, chills, malaise, dizziness, nausea, muscle cramps, and formication	1. Removing spicules with adhesive tape 2. Dilute acetic acid soaks 3. Topical versus oral steroids
	Second syndrome: includes erythema multiforme/dyshidrotic eczema and anaphylaxis	No treatment for prevention
Fire coral	Cutaneous: burning/itching, erythema, necrotizing, or granulomatous reactions	1. Cleansing with seawater
	Systemic: myalgias, fever, malaise, nausea, and vomiting	2. Debridement 3. Acetic acid soaks
Physalia	Cutaneous: significant edema and necrosis, and pain	1. Pacific Ocean, Gulf of Mexico, and western Atlantic Ocean stings — acetic acid
	Systemic: abdominal pain, nausea/vomiting, muscular spasm, headache, confusion, and can cause respiratory distress in severe situations	2. Stingose 3. Baking soda, papain, bromelain 4. Hot water immersion
Linuche	''Sea bathers eruption'' — self-limiting pruritus	Topical steroids
Coral	1. Inflammatory dermatitis, chronic infections	Removal of debris, antibiotics
C. fleckeri — box jellyfish	Cutaneous: painful purple linear plaques, edema, erythema	1. Hot water immersion
	Systemic: cardiac failure, pulmonary edema, and respiratory distress	2. Acetic acid 3. Antivenom
C. barnesii	Irukandji syndrome: pain, headache, backache, joint pain, nausea, vomiting, pulmonary edema, heart failure, and in some cases, intracerebral hemorrhage	1. Cold packs 2. Seawater compresses 3. Hot water immersion 4. Acetic acid 5. Antibiotic prophylaxis 6. Hospitalization for severe symptoms 7. New developments in cone snail venom (conotoxin) for treatment
Sea lilies, brittle stars, star fish, sea urchins	Pain, bleeding, erythema, edema	1. Hot water immersion 2. Analgesic pain control
Bristle worm	Pain, erythema, burning	1. Taping to remove spines 2. Antibiotics 3. Antihistamines 4. Topical steroids/medrol dose pack
Cone snail	Tetany, respiratory distress, hypotension	Intubation and critical care monitoring
Stingrays	Mechanical: pain, edema, bleeding, fat and muscle hemorrhage, and necrosis. Mechanical trauma to abdomen or thorax, or arterial laceration.	1. Hot water immersion 2. Bleeding control 3. Antibiotics 4. Hospitalization if needed.
	Systemic: nausea, vomiting, diarrhea, muscle cramps, tachycardia, hypotension, arrhythmias, seizures and even death	

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Table.
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Stonefish	Cutaneous: erythema/pallor/cyanosis → vesicles/ edema → local necrosis Systemic: severe edema, hypotension, myotoxicity, and can lead to pulmonary edema	Antivenom
Weeverfish	Sharp stabbing pain, severe burning	Hot water immersion, oral analgesia, and antihistamines
Catfish	Pain, bleeding and infection, swelling, and can cause necrosis	Spine removal, hot water immersion, consider antibiotics
Sea snakes	Painful muscle movement, lower extremity paralysis, arthralgias, trismus, blurred vision, respiratory arrest, and sometimes, death	1. Do not use cold water 2. Hospitalization 3. Antivenom

injury create localized pain, edema, and bleeding in victims. Fat hemorrhage, muscle hemorrhage, and tissue necrosis are not uncommon (2). Systemic symptoms frequently include nausea, vomiting, diarrhea, and muscle cramps, while tachycardia, hypotension, arrhythmias, and seizures are less common (2,14). Mechanical trauma to the abdomen or thorax or an arterial laceration can be fatal (14). Treatment of cutaneous injuries includes hot water immersion, removal of foreign body, and analgesic pain control (14). A retrospective clinical review by Clark *et al.* (9) showed that hot water immersion was effective for pain control in 88% of 119 cases. In this same study, antibiotic prophylaxis was helpful in preventing wound infections. The study, however, was limited by its retrospective nature, and more studies need to be conducted before antibiotic prophylaxis can be standardized. It is prudent however to monitor the patient's wound at follow-up 1 wk after envenomation and initiate antibiotics for signs of secondary infection.

Scorpionfish/Lionfish/Stonefish

Scorpionfish (Scorpaenidae), lionfish (*Pterois*), and stonefish (*Synanceia*) are poisonous fish known for their dorsal pelvic and anal spines capable of secreting venom. These species, most often seen in the tropical waters of the Indian and Pacific Oceans, but also found in the Caribbean, typically avoid human contact. As such, envenomation by these species is usually a defense mechanism provoked by fisherman and curious divers.

The stonefish (Fig. 3) is known for its ability to camouflage, blending in seamlessly with its marine surroundings. Stonefish have venom-secreting spines that cause increased capillary permeability in humans who are stung. Thus victims of stonefish envenomation are subject to severe edema, hypotension, myotoxicity, and pulmonary edema (14).

Wounds manifest initially as erythema or pallor followed by cyanosis. They then progress to vesicles accompanied by significant edema. In terminal stages, the wounds become locally necrotic (2,14). Initial treatment includes removal of spines from the skin and hot water immersion of the affected extremity. Antivenom is available for stonefish envenomation and should be given in the event of a sting. Tetanus prophylaxis should be updated. Antibiotics should be administered only in the event that wound follow-up is suspicious for signs of secondary cutaneous infection (14). A retrospective review in 2009 in Singapore concluded that stonefish envenomations while causing extreme pain and swelling were rarely lethal and could be treated symptomatically as mentioned (21).

Recent *in vitro* and *in vivo* studies by Gomes *et al.* (15) showed that there may be some similarities between stonefish and scorpionfish venom. Furthermore there may be cross-reactivity of stonefish antivenom to scorpionfish venom. Currently there is no specific antivenom for scorpionfish. Although further study is needed, this could be potentially beneficial treatment if stonefish antivenom could be used to neutralize scorpionfish envenomation.

Other Vertebrates

Weeverfish are found to be native in the UK. Like many venomous aquatic species, they usually envenomate as a result of being stepped on. Symptoms include initial sharp stabbing pain and severe burning. Pain is relieved usually with hot water immersion, oral analgesia, and antihistamines (11).

Catfish, both marine and fresh water, are capable of inflicting both mechanical and chemical damage with either their single dorsal or bilateral pectoral fin spines. Often stings occur when the fish is being handled. The mechanical trauma can cause pain bleeding and infection. The spines are enveloped in a toxic glandular tissue, which causes pain and swelling, and can cause necrosis also. Rarer adverse effects include lymphedema, adenopathy, lymphangitis, weakness, syncope, hypotension, and respiratory distress. Hot water immersion therapy, as well as treating secondary infections and ensuring complete removal of the spines, is essential (2).

Sea Snakes

Sea snakes are another aquatic vertebrate known for their envenomation. They are recognizable by their flattened, paddle-like tail that allows them to undulate in water facilitating rapid forward and backward movement. The presence of scales, but absence of fins and gills, distinguishes them from eels (2). Swimmers are rarely victims of sea snake envenomations in open water. Instead bites typically occur when people handle sea snakes or disentangle them from a net. Victims display between 1 and 20 small fang marks. The bites usually do not cause localized pain. Although bites can be painless, there is the potential for severe systemic symptoms to develop. These symptoms include painful muscle movement, lower extremity paralysis, arthralgias, trismus, blurred vision, respiratory arrest, and sometimes death. It is important not to place ice on the bite of a sea snake, as cold therapy may worsen symptoms. Victims of sea snake bites should be transported immediately to a hospital with ICU capability to support ventilation (as needed) and evaluate for antivenom administration. Fortunately antivenom is available to treat most sea snake envenomations (2) (Table).

CONCLUSION

Aquatic envenomations are a key topic in sports medicine. Human and marine interaction is ever present in daily life, be it through aquatic sports or through marine-centered occupations. Many of these injuries can have severe adverse effects, but often, treatments can be very basic and can be easily accessible. Knowledge and preparation can be the key to successful treatment in many envenomations.

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