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## Clinical Reviews

### ENCOUNTERS WITH VENOMOUS SEA-LIFE

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□ **Abstract—Background:** Sea-life with envenomation capabilities are quite abundant and diverse worldwide, being predominantly found in tropical waters. Most envenomations occur not as an attack, but as a result of self defense when the animal perceives danger; and often when locals or tourists are engaged in recreational activities. Most of these cases have only minor injuries, and few are fatal. **Objectives:** To describe the impact, clinical features, and management of life-threatening marine envenomations. **Discussion:** Recognition of the injury and identification of the responsible animal is crucial for quick and successful management. Medical professionals should be cognizant of presenting symptoms such as respiratory distress, muscle paralysis, or cardiovascular decompensation. For these patients, antivenom should be given immediately if available, followed by pharmacological and physical therapy to relieve symptoms and pain. If any foreign bodies are left at the site of the injury, they must be removed. Tetanus prophylaxis should also be considered in case of puncture, and if signs of early infection are present, broad-spectrum antibiotics should be administered. **Conclusion:** Management of envenomations from marine animals should be emphasized not only to health centers, but also to the general population, so that initial treatment can be started as soon as possible. Educational programs regarding risks and initial management for these incidents are also recommended to reduce the incidence and associated morbidity and mortality of the encounters. © 2011 Elsevier Inc.

□ **Keywords—marine envenomations; jellyfish; stonefish; cone snail; blue ringed octopus; antivenom; stingray**

#### INTRODUCTION

Sea-life with envenomation capabilities are quite abundant and diverse worldwide; they are predominantly found in tropical waters. Each year, thousands of injuries from stingrays and jellyfish take place (1–3). Fortunately, few of these reported incidents are fatal (4–7). Envenomations from the scorpion fish family or mollusks are not as common as envenomations from jellyfish or stingrays. Venomous lesions from aquatic creatures vary greatly in presentation; they range from simple, mild, localized pain with erythema and papulovesicular eruption, to severe shock and death (Table 1). This article will review animals with envenomations that are associated with a high rate of morbidity and with serious, life-threatening events.

#### DISCUSSION

##### *Coelenterates*

There are approximately 10,000 species of marine coelenterates, of which more than 100 are considered dan-

**Table 1. Presentation, Complications, and Management of Various Life-Threatening Marine Envenomations**

Offending Animal	Common Signs and Symptoms	Complications	Treatment	Antivenom
Box jellyfish ( <i>Chironex fleckeri</i> )	Itchy red maculopapular rash, burning pain, edema, and the classical ladder-rung pattern lesion	Cardiotoxic effect, nerve palsy, hemolysis, cardiopulmonary decompensation, shock, and death	Vinegar irrigation, hot water shower as tolerated for 10–20 min, pain management (including local use of cold packs/ice and opiates), and supportive care. Do not use pressure immobilization bandages	CSL-antivenom. If there is cardiac or respiratory decompensation give a minimum of 1 ampule of antivenom i.v. (20,000 units diluted 1:10 with normal saline). Up to 3 ampules may be given consecutively if response is inadequate in addition to magnesium sulfate bolus i.v.
Irukandji jellyfish ( <i>Carukia barnesi</i> )	Severe abdominal, chest, limbs, or back pain; generalized muscular pain, hypertension, tachycardia, vomiting, nausea, diaphoresis, piloerection, and local erythema	Hypertensive crisis, hemodynamic decompensation with abnormal ECG and elevated troponins, cardiac failure, and death	Hot water shower as tolerated for 10–20 min, vinegar irrigation, antihypertensive therapy, magnesium sulfate i.v., and pain management (including local use of cold packs/ice and opiates). Do not use pressure immobilization bandages	Unavailable
Portuguese man-of-war ( <i>Physalia physalis</i> and <i>Physalia utriculus</i> )	Local sharp pain immediately after the sting, followed by an erythematous maculopapular linear rash, local edema, and numbness	Skin necrosis, cardiorespiratory collapse, and rarely death	Remove tentacles, preferably with forceps or gloved hand. Avoid using vinegar or methylated spirits. Hot water (45°C) immersion for 10–20 min preferred over local application of ice-packs for pain control. Topical anesthetics can be considered after successful removal of all tentacle fragments. Use oral or parenteral analgesics if pain persists	Unavailable
Cone snail ( <i>Conus geographus</i> )	Severe pain at site of sting, muscular paralysis	Respiratory arrest in 40 min to 5 h	Urgent intubation and critical care management	Unavailable
Blue-ringed octopus ( <i>Hapalochlaena lunulata</i> )	Flaccid paralysis and hypotension	Respiratory failure and death	Supportive care including mechanical ventilation	Unavailable
Stonefish (Family: <i>Scorpaenidae</i> )	Severe pain and edema at site of sting, headaches	Weakness, syncope, dyspnea, hypotension, and hallucinations	Hot water immersion as tolerated, NSAIDs, local analgesia, debridement if needed, and prophylaxis with antibiotics	CSL stonefish antivenom. Administration of 2000 units for every 1–2 punctures, with a maximum of 3 ampules. (Its use may also be beneficial in other Scorpaenidae envenomations)
Stingray (Family: <i>Dasyatidae</i> )	Pain and laceration at puncture site, nausea, vomiting, muscle cramps	Hypotension, dysrhythmia, arterial lacerations, thorax, and spinal cord trauma	Hot water immersion as tolerated, systemic and local analgesia, debridement, and prophylaxis with antibiotics	Unavailable

CSL = Commonwealth Serum Laboratories; i.v. = intravenous; ECG = electrocardiogram; NSAID = non-steroidal anti-inflammatory drug.

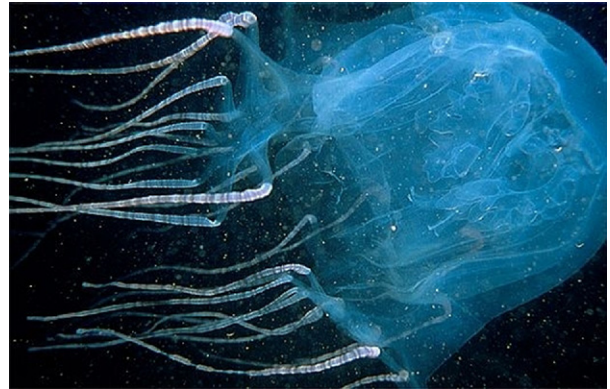
gerous. Creatures of the phylum *Cnidaria* are carnivores containing venom-charged nematocysts. Phospholipase A2 (PLA2), an enzyme found in the venom of many snakes, has also been identified in all classes of the phylum *cnidaria*, including the box jellyfish (*Chironex fleckeri*) and the Irukandji (*Carukia barnesi*) (8,9). Whereas many of the creatures in the phylum *Cnidaria* are known to be venomous, the Irukandji and box jellyfish have a high incidence of mortality associated with their stings.

*Chironex fleckeri* (*box jellyfish*). The box jellyfish, also known as the sea wasp and marine stinger, is native to the Western Australian coast, across the Northern Territory coast and down the east coast of Queensland, and is predominantly seen during the summer months (10). This feared and deadly animal has accounted for at least 67 deaths in Australia (11,12).

Large doses of box jellyfish venom can produce a rapid cardiotoxic effect and can present with an absence of electrocardiographic abnormalities (13,14). In severe cases, the patient decompensates and collapses within minutes, and often by the time medical attention is available, the patient is beyond recovery. Delayed hypersensitivity reactions from jellyfish stings, including box jellyfish, present with an itchy red maculopapular rash after several days or weeks in more than half of the victims (15,16).

A recent prospective study of 225 confirmed stings from the box jellyfish by Currie and Jacups revealed that 92% of the stings took place between October 1 and June 1 (i.e., stinger season), 83% were in shallow water (<1 m), and were significantly more common between 3:00 p.m. and 6:00 p.m. ( $p < 0.001$ ) (4). In almost all reports, the onset of pain was immediate. Approximately half of the study population reported pain intensity as moderate, and one-fourth stated it to be severe. One-third of the patients required parenteral narcotics despite the induction of vinegar and cold ice-packs, and 8% of stung patients required hospitalization. There have been reports of >65 deaths that occurred over this last century as a result of jellyfish stings (17,18). In the aforementioned study, a 3-year-old child died as a result of a box jellyfish sting. In addition, the authors related that two additional deaths outside the scope of the study were also reported. The authors went on to state that the last 10 deaths from jellyfish envenomations were all children. This is most likely related to the smaller body mass contacted by the nematocysts, producing a more virulent effect (19).

It is important to differentiate the box jellyfish sting from others in its species, as response to therapeutic interventions may vary (20). It may be helpful to perform a rapid inspection of the affected area, to look for the characteristic cross-hatched ladder pattern lesion (Figure



**Figure 1.** Box jellyfish (*Chironex fleckeri*). The animal's tentacles with the characteristic ladder-like pattern. Figure printed with permission of Dr. Zoltan Takacs.

1) (21). Microscopic identification of the jellyfish species is also helpful in deciding the best approach to treatment, including possible need for antivenom (15,22). Two methods to identify the box jellyfish sting have been described; the skin-scraping method with a blade and the sticky tape method used for nematocyst identification. The latter method is considered faster, easier to perform, and more accurate, with one study showing positive results in 85% of patients studied ( $n = 20$ ) (22). Another study demonstrated positive identification results in 74% of patients ( $n = 39$ ), but identification can still be difficult if the skin lesion is small (15,22).

*Carukia barnesi* (*Irukandji*). This small bullet-shaped medusa containing four contractile tentacles was first captured by Barnes in 1961 (23). It is responsible for the Irukandji syndrome described previously by Flecker in 1952, and it is named after an aboriginal tribe that inhabited the coastal waters around Cairns, where most of the cases had been reported (24). The Irukandji is found in Australia along the northern and western coasts. The size of the bell of this animal ranges from 3 to 19 mm (25).

The stingers (nematocysts) from this creature are found not only on the tentacles but also on the bell of this carybdeid (23). Although nematocysts found on the bell are morphologically different from those on the tentacles, they can also cause envenomation (26).

The most common initial signs and symptoms after Irukandji sting include raising a wheal, local erythema at the sting site, severe abdominal, chest, limb, or back pain, cough, nausea, vomiting, and generalized muscular pain; followed by symptoms of sympathetic hyperactivity (e.g., sweating, hypertension, tachycardia, piloerection, and mild pyrexia), which can lead to cardiac failure and pulmonary edema. Other infrequently re-

ported symptoms included tingling, shivering, weakness, cramps, headache, and dry mouth (23,24,26–28). Envenomations of cells in vitro and in vivo by the Irukandji toxin have been followed by excessive release of epinephrine and norepinephrine (26,29,30). The time before symptoms occur can vary from 2 to 20 min, or even longer in rare cases (23,24). These encounters usually take place in shallow water during the afternoon (24). In a report of 61 cases, it was recorded that the most common sites of injury were the legs, followed by chest and arms (26).

Many have theorized that Irukandji syndrome may not be caused exclusively by *Carukia barnesi* (31–35). There is a reported case of Irukandji syndrome caused not by *C. barnesi*, but by a similar unnamed jellyfish (33). Likewise, there are other reports that suggest that Irukandji syndrome may be caused by other jellyfish, commonly called “fire jellies,” such as *Alatina nr mordens*, *Malo maxima*, *Carybdea alata*, and *Carybdea xaymacana* (34). A case in Southeast Asia and three cases in South Florida have been reported with “Irukandji like” syndrome, but because there was no microscopic confirmation, and due to the unusual geographical presentation, these cases were not confirmed as Irukandji syndrome (36,37). In the future, more research will be necessary to more accurately identify the types of stings produced by each species (32).

Two tourists died in Australia in 2002 from intracerebral hemorrhage after presenting with severe hypertension and classic Irukandji symptoms caused by jellyfish envenomation (27). Although no confirming data are available, the location and presentation of these cases seems to be typical of presentation of Irukandji envenomation (5).

*Coelenterate sting treatment recommendations.* Every year many patients are envenomed in beachfront areas, where access to medical assistance is not available (13). Severe dyspnea due to upper airway obstruction, acute myocardial infarction, nerve palsy, granuloma formation, paralytic ileus, and elevated troponin I levels without cardiac disease are considered uncommon, but possible, reactions to jellyfish stings (11,31,35,36,38–41).

An advantage to marine venoms is that they generally contain heat labile proteins that can be denatured quickly with inexpensive treatment, usually with hot water (2). Supporting this, other evidence suggests that the lethal toxins of *Chironex* are proteins that can be denatured with heat (42). Carrette et al. demonstrated in an animal model that higher temperatures and longer exposure time of *C. fleckeri* venom to heat had a significant decrease in lethality ( $p < 0.0001$  and  $p < 0.0001$ , respectively) (43). Venom exposure for 20 min at 48°C, or 2 min at 53°C, was enough to avoid death. Conversely, when exposures

were between 4°C and 39°C, no change in venom toxicity was achieved, even with exposures >20 min (43). Although this may seem an impractical treatment due to potential skin damage, as immersion in water at 48°C for 5 min may be enough to produce a severe burn, according to the American Burn Association, hot water showers as tolerated for 10–20 min could be helpful in denaturing the venom and relieving the pain. This practice has been proven useful for treating Irukandji and other jellyfish; but still there is little evidence for using hot water for *C. fleckeri* envenomations in humans, and vinegar irrigation still remains as the most widely accepted first-aid therapy for deactivation of the nematocysts (44).

Data presented by Winter et al. in a study with rats confirmed these findings by boiling the venom for 5 min before administration ( $p < 0.05$ ) (45). This intervention inhibited the hypertensive response and cardiovascular collapse. Also, a pH of 3 produced an abolished cardiovascular response ( $p < 0.05$ ), whereas a pH range of 5–9 had no effect on the venom interaction (45). Other studies support this, considering hot (not boiling) water immersion as an efficacious initial treatment for jellyfish stings (46,47).

Box jellyfish antivenom has been shown to significantly neutralize the neurotoxic effects in vitro when given before envenomation ( $p < 0.05$ ), with no significant neutralization after 1 h ( $p < 0.05$ ), suggesting there may be clinical efficacy if applied quickly after an incident with *C. fleckeri* (48).

Previous recommendations included immediate treatment after an attack from *C. fleckeri* with administration of antivenom, epinephrine, and supportive cardiorespiratory care (13). Recent data suggest that antivenom should be administered immediately to patients with signs or symptoms of cardiorespiratory decompensation (4). An in vivo study with rats showed that antivenom administered before venom from *C. fleckeri* prevented cardiovascular collapse in 40% of cases; and when antivenom was given in combination with magnesium sulfate, collapse was avoided in 100% of cases (18). The clinical significance of these findings remains unclear, but underscores the necessity for additional studies.

Nonetheless, most stings from the marine stinger are not life threatening, and therefore do not require antivenom therapy. Vinegar irrigation at the site of the sting has been accepted as part of the first aid management for both *C. fleckeri* and *C. barnesi* (21,49). It has been shown to decrease the ease with which nematocysts are triggered, and is highly available and inexpensive. Afterwards, removal of all visible tentacles should be carefully performed, preferably by a rescuer, if available (50).

Localized use of cold packs or ice has also been helpful in skin pain relief, but does not inactivate the venom. The use of cold packs or ice should be employed

after irrigation with vinegar and by covering the ice with a cloth or plastic bag to prevent the hypotonicity of water from the melting ice to trigger the firing of nematocysts (4,15,42,49,50). Narcotics can be used when application of ice-packs does not give adequate pain relief (15,22). The most common indications for antivenom administration are cardiorespiratory compromise, pain that cannot be controlled by ice-packs or narcotics, and when the area of skin involved is extensive. The antivenom may also be helpful in minimizing pain and scarring (51). The use of pressure immobilization bandages is not recommended as a standard treatment because it may worsen the envenomation by the release of additional toxins, even from already discharged nematocysts (12,52,53).

Verapamil has been reported to be useful for its calcium-channel-blocking activity in reversing cardiac injury after jellyfish envenomation, and may serve to allow additional time for administration of box jellyfish antivenom if needed (13,54). Bloom et al. showed that verapamil enhanced the favorable effect of ovine antivenom in mice (55). Conversely, a more recent study showed no effect of verapamil on calcium influx, suggesting calcium influx secondary to jellyfish venom is caused by pore formation instead of the regular L-type calcium channels (56).

Phentolamine has been useful for the treatment of hypertension, shaking, and anxiety associated with Irukandji syndrome.

Even though there are recommendations for the use of beta-blockers, their use remains extremely controversial (26). As well, some anecdotal beneficial effects from intravenous magnesium sulfate administration have been reported for treatment of refractory pain and hypertension in Irukandji syndrome, as well as for cardiovascular collapse in envenomation by box jellyfish (4,57–59). There is a need for more sustaining evidence so that we can have clearer therapy recommendations in the future.

Antivenom will most likely be the best treatment for the Irukandji syndrome; however, until a sufficient number of these animals can be captured and their venom assessed, there is no antivenom available (5). Recently, faster and more refined techniques for venom extraction have been developed, and will hopefully lead to the development of additional antivenoms (48,60,61).

#### *Portuguese Man-of-war (Physalia)*

The bluebottle, or Portuguese man-of-war, is well known by bathers in warm waters worldwide for its painful sting (50,62). Their sting is one of the most common in the southern waters of the United States, but fortunately only few deaths have been reported (63,64). This animal is not a true jellyfish; it is formed by colonies of siphonophores

(class Hydrozoa). There are two known species: *Physalia physalis* and *Physalia utriculus*. *Physalia physalis* is usually found in the warm waters of the Atlantic Ocean and has a blue float on the surface of the water that measures from 2–25 cm in length and has multiple underwater tentacles that can be up to 30 m in length. This specimen is considered more dangerous due to its size, and is thought to be responsible for the few deaths that have been reported. The second specimen, *P. utriculus*, is smaller and is more characteristic of the warm waters of the Pacific Ocean; it has a single tentacle that can be up to 3 m and has been associated with less threatening envenomations (50,62,65).

The most common presentation of an affected patient is a local sharp pain immediately after the sting, followed by an erythematous maculopapular linear rash where the tentacle made contact with the body. Other signs and symptoms are local edema and numbness, but vesicles and skin necrosis can also occur in a more remote fashion. The severity of the envenomation is proportional to the size of the tentacle and the total surface area that was injured. Usually the pain remains at the local site and improves after a few hours, with the erythema and rash also improving within the first 24 h, and complete resolution of symptoms usually within 72 h with no sequelae. Uncommon symptoms include nausea, vomiting, muscle cramps, anxiety, dyspnea, headache, abdominal pain, cardiovascular collapse, and even death (50,62,64–66).

*Portuguese man-of-war sting treatment recommendations.* Treatment for *Physalia* envenomations should be focused on preventing further envenomation, pain control, and cardiorespiratory support if needed. First, the victim must be removed from the water to prevent more injuries. Then, tentacles can be removed with the fingers or by pouring salt water over the affected area, but preferably they should be removed with forceps or with a gloved hand. Vinegar is no longer recommended in the first aid management of *Physalia* stings because it has been shown to cause some degree of nematocyst firing. As well, methylated spirits should also be avoided for the same reason (50,62,65). Both hot water immersion and local use of ice-packs covered with a plastic bag or cloth are recommended for pain control. However, hot water (45°C) immersion for 20 min has proven to be more effective in obtaining pain relief vs. local application of ice-packs in a randomized controlled trial with 96 envenomated patients (67). Local anesthetics (e.g., lidocaine ointment or benzocaine spray) can also be considered after all fragments of tentacles have been successfully removed (50,63). If the pain is difficult to control, oral or parenteral analgesics can be added as part of the management (63). In case the victim presents with hemodynamic instability or respiratory compromise, im-

mediate transportation to a health care facility for further management and life support is warranted (50,64).

### Mollusks

*Cone snail.* This small but lethal animal is considered nature's most specialized gastropod, with a complicated internal anatomy and a protective shell. The cone snail is capable of producing tetany in every species that comes in contact with its venom (2,68). Its spiraled shell emits a proboscis that contains a hollow fang-like harpoon used either for attacking prey or for self defense. This fang-like weapon quickly fills with venom, a particular set of low molecular-weight neurotoxins known as conotoxins. They are potential blockers of the muscular and neural receptors, leading to a rapid paralysis (i.e., ~50 ms) after envenomation (68–70).

This particular venom has two effects that overcome the snail's slowness in capturing prey. First, the "lightning strike" effect that consists of immediate immobilization by peptides that block the potassium and the sodium channels; and second, a much slower effect that inhibits the presynaptic calcium channels, which consequently completely blocks neuromuscular junction (69).

There are no exact data on the number of human deaths caused by the sting of the cone snail; there are approximately 50 reports in the literature (69). The cone snail sting has a mortality rate of 25%, with most encounters taking place while collecting shells for ornaments or feeding (70). Once the toxin is injected, the patient experiences severe pain at the site of the sting. It advances rapidly into a progressive paralysis, noted by palpebral ptosis, speech difficulty, and swallowing impairment. In rare fatal cases, the patient develops respiratory arrest in 40 min to 5 h (69–71). No current antivenom exists for the sting of the cone snail; the only option for the treatment of the victim is urgent intubation and critical care management.

*Cone snail envenomation treatment recommendations.* To date, there is no antivenom to eliminate the effects of the conotoxins. The only therapeutic option for a patient stung by a cone snail, particularly in cases with respiratory arrest, is urgent intubation and admission of the patient to a critical care setting (69). During the hospitalization, the patient should be referred to surgical care for excision and drainage if the affected area is at risk for necrosis.

*Blue-ringed octopus.* Attacks to humans by the blue-ringed octopus usually occur out of the water (72). In its natural environment, the octopus discharges the venom into water and paralyzes its prey. Envenomation of hu-

mans is typically the result of self-defense when the animal is picked up out of the ocean by curious bathers, often as a result of its rare and uncommon appearance (i.e., a brownish body covered by blue spots, or rings, that light up whenever it feels threatened) (72).

A study performed in 2006 by Yotsu-Yamashita et al. showed that the blue-ringed octopus has a significant concentration of venom throughout its body, not just in its tentacles (73). The creature is also immune to its own venom. The process of envenomation starts when the octopus stings the victim with its beaks, connected to the posterior salivary glands, which contain the venom. The beaks deposit venom approximately 5 mm under the dermis, which results in immediate distortion of the tissue due to the great pressure with which it is injected (74).

The injected toxin has many components, the most harmful being tetrodotoxin, one of the most deadly toxins in the world (75). Tetrodotoxin blocks the sodium channels along the cell membrane and although it has no direct effect on the neuromuscular junction, it results in a flaccid paralysis leading to respiratory failure and death (74). In addition, hypotension is produced by direct action on vascular smooth muscle (76).

*Blue-ringed octopus envenomation treatment recommendations.* As is the case with conotoxins, there is no specific antivenom for the tetrodotoxin. A patient that presents with symptoms of respiratory failure should be placed on mechanical ventilation and should receive supportive care (77). Supporting this, a case report of a 4-year-old envenomated by this octopus had a satisfactory outcome with no long-term consequences after prompt intubation and appropriate supportive therapy (78). The affected limb should be elevated and direct pressure should be applied at the site of the attack so the toxin does not spread via the bloodstream, and eventually lymphatic circulation (79,80).

### Venomous Fish

*Stonefish, scorpion fish, and lion fish.* Commonly known as the stonefish, *Synacea sp.* is the most venomous of the scorpion fishes (81). It inhabits the superficial waters of the Indo-Pacific region, where it commonly encounters man (81). The stonefish regularly grows up to 38 cm and weighs 1.5 kg. It is usually found in nature as a brown-to-green fish with stone-like eminences and deep holes around the head. It is characteristically covered with a slime that allows the animal to be covered by algae and other organisms, which camouflage the stonefish and thus make detection and avoidance very hard (3).

The body of the stonefish is covered with multiple spines, generally 13 dorsal, two pelvic, and three anal,



**Figure 2. Stonefish.** This camouflaged animal can easily be confused with a rock or coral from the bottom of the sea. The dorsal spines shown contain dangerous venom that could threaten a person's life.

and venom is released from two lateral glands in every spine base upon mechanical pressure. This is a defense and self-preservation mechanism that is not used for attacking prey (Figure 2) (82). The venom of the stonefish is one of the most powerful known to man, comparable in potency to that of the cobra (83).

The stonefish inflicts its defensive damage first through a wound produced by the spine of the fish, which introduces the venom into the tissue. The injected venom then increases capillary permeability, inducing severe edema of the affected limb. The lethal portion of the venom is a highly hypotensive agent with myotoxic and neurotoxic components (84). Systemic effects may present as muscle weakness, syncope, dyspnea, headaches, and hallucinations (81). Fortunately, there is an antivenom available; however, the diagnosis must be done by clinical correlation, and tetanus prophylaxis should be started (85). Other members of the scorpion fish family are also venomous, the most well known being the lion fish. As with many other species in nature, the scorpion fishes have an attack-defense mechanism that includes the secretion of venoms and other toxic substances with biological actions (86).

The lion fish, a well-known exotic fish, is also capable of causing envenomation injuries when contact is made with its venomous dorsal, anal, and pelvic spines (Figure 3). These wounds often occur to the hands of those trying to manipulate the fish. Lion fish venom is the weakest of the scorpion fish family, yet it still creates a sharp, intense, throbbing pain that radiates to other areas beyond the puncture site (83). Along with the other members of its family, wounds from this fish can be divided into three grades, depending on the severity: 1) erythema, pallor, ecchymosis or even cyanosis are the first

events that present, and result from the increased capillary permeability; 2) vesicle formation, as an effect of the toxins; 3) local necrosis observed within days, which is considered a grave complication and requires debriding (87). If left untreated, the pain may persist for days or even weeks. Systemic effects can be very similar to those of the stonefish, and are always relative to the concentration of venom injected into the victim (87,88).

Mostly found in the coastal waters of the Atlantic Ocean (usually Brazil, Uruguay, and Argentina), the scorpion fish remains an understudied fish due to its limited global distribution (89). The spines of the scorpion fish are strong, short, and have more developed glands than the lion fish (90). Like its "cousin" the scorpion fish, the lion fish is able to generate a proteinaceous venom, with cardiotoxic and neurotoxic effects (91).

*Stonefish, scorpion fish, and lion fish envenomation treatment recommendations.* Specific antivenom is available for the different species of scorpion fish and helps in relieving the pain and systemic effects of envenomation. The dose is 2000 units for every one to two punctures, with a maximum of three ampules for more than four punctures (85).

All the spines must be removed, and the affected limb must be elevated and cleaned with clear running water. Afterwards, direct pressure should be applied to prevent excessive bleeding. The affected limb should be immersed in water heated to an approximate temperature of 45°C (never boiling water) to relieve acute pain. In addition, supplemental local or oral analgesia may be administered. Tetanus prophylaxis should also be administered and the patient should be observed for 6–12 h. Plain radiographs to ensure the removal of all spines should also be performed. There is no need for antibiotic



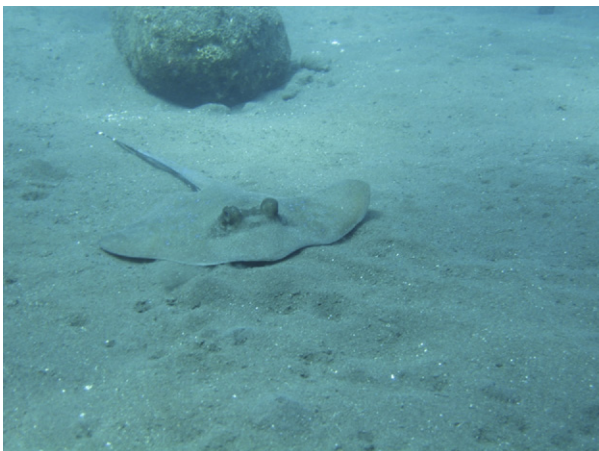
**Figure 3. Lion fish.** This fish has many long dorsal and fin spines, all containing venom.

prophylaxis, even though antibiotics are required if there is any sign of infection or if Gram-positive bacteria are noted (81,83,87).

*Stingrays.* Stingrays belong to the *chondrichthyes* family along with sharks and skates. They are broad, flat creatures with a whip-like tail. They are inhabitants of the tropical warm waters and are found practically all over the world (2,92). There are approximately 11 different species of stingrays in the coastal waters of the United States, and about 150 species worldwide (92). Encounters with stingrays cause approximately 2000 visits to the emergency department each year in the United States, though most do not jeopardize the life of patients (7). Stingray attacks often occur as a defense mechanism when the animal is feeling threatened or being stepped on, as the stingray is often buried in the sand (2,7).

The mechanism by which the stingray causes damage is divided into two phases. In the mechanical phase, the fish lashes its tail towards the victim and the sharp, serrated spine is left at the site of injury, or in some cases the spine breaks and fragments are left embedded in the tissue. In the second phase, venom from a gland at the tail base is injected into the victim, causing almost immediate effects (Figure 4) (7,93). Some patients can develop systemic symptoms such as excessive salivation, nausea, vomiting, diarrhea, muscle cramps, hypotension, dysrhythmias, and in rare cases, death (7).

The most severe complication of a stingray attack is arterial lacerations that may lead to hemorrhage, or spinal cord trauma (7). There have been reports of deaths caused by the stingrays, when the lacerations are in the thorax or the abdominal cavity, but rarely due to the envenomation (94,95). Weiss and Wolfenden in 2001 reported a case of a 33-year-old man who survived a



**Figure 4.** Stingray. The whip-like tail of the animal contains a spine that functions as a defense weapon.

cardiac injury from stingray barbs; however, the majority of attacks resulting in cardiac injury have a high incidence of mortality (94–97). If the barbs or spine of the tail breaks inside the victim, it may lead to secondary infection, or in severe cases, necrotizing fasciitis (98). Therefore, it is important to remove all foreign bodies left after the attack.

*Stingray envenomation treatment recommendations.* Most commonly, the site of stingray attack is a limb, but the physician should be cognizant of the systemic effects of the venom and treat immediately. If systemic symptoms are not present, the first therapeutic goal is to relieve the pain by immersing the affected area in hot water. As with the envenomation by the scorpion fishes, this may also serve to reduce the possibility of necrosis (99). The use of oral and local analgesia as needed is also recommended (93). The wound should be explored in search of any foreign body that can lead to further infection. Plain film radiography should also be performed to help rule out foreign body (7,93). If there are signs of necrosis at the wound, the affected area must be debrided, and antibiotic treatment should be started.

#### *Treatment Recommendations Overview*

An overview of the signs, symptoms, complications, and management of various life-threatening marine envenomations described above is presented below and in Table 1. It is worth mentioning that the Department of Pharmacology from the University of Melbourne, Australia has the Australian Venom Research Unit with a 24-h advisory service for physicians regarding marine envenomations for the pre-hospital and in-hospital settings.

## CONCLUSION

Most incidents of marine animal envenomation occur not as an attack per se, but as a result of self-defense. Recognition of the injury is a crucial first step for quick and successful management. Medical professionals should pay particular attention to presenting symptoms such as respiratory distress, muscle paralysis, or cardiovascular decompensation. For these patients, antivenom must be given promptly if available, along with critical care management, followed by pharmaceutical and physical therapy to relieve symptoms and pain. If any foreign body is left at the site of the injury, it should be removed promptly. Tetanus prophylaxis should also be considered with puncture wounds, and if signs of early infection are present, broad-spectrum antibiotics should be administered.



Antivenoms against the box jellyfish and stonefish toxins have been developed and it is hoped that their availability will continue to spread. Scientists continue to work to develop antivenoms for conotoxin and tetrodotoxin. In the absence of antivenom, therapeutic options may include use of hot water, analgesia with non-steroidal anti-inflammatory drugs or narcotics, and critical supportive care.

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