

Stingray Injury to the Webspace of the Foot

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abstract

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Stingrays are cartilaginous fish that are related to sharks. They are one of the largest groups of venomous marine animals. Stingrays account for 750 to 2000 injuries annually. They are generally passive, reclusive creatures that only sting in self-defense. Most injuries caused by these animals are nonfatal. A stingray possesses between 1 and 4 venomous stings, which are located along the caudal spine. If a stingray injury is sustained, parts of the spine may be left in the lacerations, which prolongs exposure to venom and increases the risk of subsequent wound infection. Stingray venom is unique in its enzymatic composition and results in distinct soft tissue injury patterns. Typically, a pattern of acute inflammation occurs, with a predominantly lymphoid cellular infiltrate followed by necrosis. The environment in which stingray injuries occur presents unique bacterial flora, and subsequent wound infections require careful antibiotic selection.

This article describes a case of a healthy 31-year-old woman who sustained a stingray injury to the webspace of the foot while in Costa Rica. Initial basic first aid measures were applied. However, the wound subsequently became infected, and formal irrigation and debridement were performed. The initial wound cultures grew *Staphylococcus viridans*. Two months postoperatively, the incision was well healed, and the patient was pain free and returned to work.



Figure: Postoperative photograph of the wound at 1-month follow-up.

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Stingrays are cartilaginous fish that are related to sharks and account for 750 to 2000 injuries annually in the United States.¹ They are generally passive, reclusive creatures that use their stings in only self-defense. These venomous marine animals inhabit warm, temperate, subtropical, and tropical waters worldwide.² Most injuries caused by stingrays are nonfatal. If a fatality occurs, it is usually due to exsanguination or the penetration of a vital organ. Reported fatalities range from 1 to 2 cases or fewer per year in the United States.^{1,3}

A stingray possesses between 1 and 4 venomous stings, which are located along the caudal spine. This part of the spine can measure up to 37 cm in length⁴ and is a bilateral retroserrate cartilaginous structure that extends as a whip-like tail.¹ When struck by a stingray tail, a nonvenomous injury may be sustained. If the integument over the spine ruptures, a venomous injury may occur. On penetration, parts of the spine may be left in lacerations, which prolongs exposure to venom and increases the risk of subsequent wound infection. This article describes a case of a stingray injury to the webspace of the foot.

CASE REPORT

A healthy 31-year-old woman sustained a penetrating stingray injury to the dorsal aspect of the proximal first webspace of her left foot during a vacation in Costa Rica. Initial medical care consisted of the injury's immersion in hot water, with regular irrigation from other members of the vacation party, all of whom were nurses. No formal medical attention was sought in Costa Rica.

On returning to the United States, she presented to another hospital. Two incision and drainage procedures were performed. The first procedure was performed 13 days following the initial injury, and purulent material was evacuated. Twenty-nine days following the initial injury, a second incision and drainage procedure was performed, with minimal fluid release.

Cultures of the drained material grew *Staphylococcus viridians*. During treatment at the other hospital, she had received cephalexin, doxycycline, and levofloxacin. The patient was allergic to amoxicillin and sulfa-based antibiotics.

The patient presented to our office 35 days after initial injury and reported night sweats, chills, and continual drainage from the open wound. Her pain level was constant, rated as 2/10 at rest and reaching 10/10 at times. Examination revealed an open wound to the dorsal aspect of the foot at the proximal end of the first webspace. The wound was surrounded by an erythematous ring and was tender to palpation in a surrounding 1-cm circumference. The surrounding tissue was edematous. Serosanguinous fluid was easily expressed from the wound. The patient underwent formal irrigation and debridement that same day.

The patient was placed in a supine position under sedation and an ankle block. Chronic fibrotic changes and necrotic fatty tissue existed along the tract of barb penetration. The capsule to the first metatarsophalangeal joint was intact. The wound was explored to the transverse metatarsal ligament, and no deeper infection existed. All necrotic tissue was excised.

Following thorough irrigation with 0.9% saline, cultures were taken for aerobic and anaerobic bacteria, fungus, and mycobacterium. Tissue was sent for gross and microscopic examination, and the foot was examined under fluoroscopy. On initial examination, a possible foreign body appeared to exist under the second metatarsal head. However, this was confirmed to be a sesamoid bone in the plantar plate. The wound was left open and packed with gauze.

The patient was examined 4, 8, and 12 days postoperatively. The patient reported making good progress, performing dressing changes herself, and ambulating in a stiff-soled postoperative shoe. The wound was improving, and granulation tissue existed. Bacterial cultures and gram stain were negative. Figure 1 demonstrates the



Figure 1: Postoperative photograph of the wound at 1-month follow-up.



Figure 2: Postoperative photograph of the wound at 3-month follow-up.

wound's appearance 1 month postoperatively.

At 2-month follow-up, the patient was pain free and had returned to work, as well as biking and hiking activities. The incision appeared to be well healed, with no evidence of residual infection. All culture results remained negative. Figure 2 demonstrates the wound's appearance 3 months postoperatively.

DISCUSSION

Stingrays are one of the largest groups of venomous marine animals, and approximately 150 different species exist worldwide. They are nonaggressive fish and are often buried beneath the sand. Humans have entered the stingray's habitat by pursuing aquatic occupations or activities, such as diving and fishing.

Stingray injuries usually occur to young males and to the extremities, par-

ticularly the dorsal aspect of the foot, ankle, leg, and hands.⁵⁻¹⁰ Envenomation from a freshwater stingray can be more severe than a marine stingray.¹¹ However, up to 45% of stingrays have lost or torn their integumentary sheaths and are therefore not capable of a venomous sting.¹

Stingray venom can be dangerous. Venom sufficient to cause a 1.5-half inch wound, injected intravenously into a rabbit, is fatal within a few minutes. The intravenous median lethal dose has been established at 28 mg/kg of body weight. In small doses, the venom acts as a vasodilator but then exerts vasoconstrictor properties.¹² The systemic manifestations of envenomation are intense pain, salivation, anorexia, nausea, vomiting, diarrhea, muscle cramps or tremors, tonic paralysis, dyspnea, seizures, headaches, and hypotension. Cardiac arrhythmias also occur, including first, second, and third atrioventricular block or asystole, due to the cardiotoxic nature of the venom.¹² In sufficient doses, the venom causes cardiac dilatation and failure. The exact molecular mechanism of cardiotoxicity is unknown.¹

Following a stingray injury, initial management should consist of maintaining hemodynamic stability and appropriate life-saving measures, which may include treatment for anaphylaxis. The wound should be thoroughly irrigated because venom is water-soluble, which will also assist in eluding foreign bodies, such as parts of the stingray spine. At the accident scene, sea water can be used for irrigation.^{2,13-15} Parts of the spine can be removed if they are superficially embedded. If suspicion exists of deeper penetration, the spine should be left in situ.¹ Hemorrhage can be stemmed with local pressure.

Stingray venom is heat labile and can be inactivated by hot water. It has been suggested that the injured extremity should be submerged in warm water, at a temperature between 42° and 45°C (108° and 113°F), so that it does not cause a scalding burn. The limb should be immersed for 30 to 90 minutes or until the

pain resolves.^{2,13-15} Although warm water immersion has not been proven in randomized controlled trials as safe or effective,¹ studies have shown that irrigation and warm water immersion have a beneficial effect on the amount of tissue necrosis that ensues.^{16,17}

Typically, the wound bleeds profusely in the first moments following injury, appears erythematous, and changes to a bluish gray or cyanotic hue. Petechiae appear, and the local tissues and whole limb may become edematous. Hemorrhagic discoloration and blisters appear as the tissues become necrotic. Tissue necrosis likely results from the unique enzymatic composition of stingray venom due to its caseinolytic and gelatinolytic enzymatic components, as well as possessing vasoconstrictor properties.¹⁸ The unique inflammatory cell infiltrate, composed mainly of lymphoid cells, CD3+ and CD4+ lymphocytes, and eosinophils, along with their secretory mediators, may be responsible for the pattern of acute inflammation, followed by necrosis, delayed healing responses, gangrene, botulism, osteomyelitis, and necrotizing fasciitis.^{13,19,20}

The wound should be left to heal via secondary intention or delayed primary closure due to the risk of infection. Alternatively, the wound may be closed with a drain in situ. Patients may require hospital admission to monitor for signs of respiratory or cardiovascular collapse for at least 4 hours.^{2,13,14} Tetanus prophylaxis should be administered.

If the patient displays systemic signs or has sustained a deep penetrating wound, he or she should be transferred to a facility capable of critical care management with appropriate surgical teams. A local injection of lidocaine without epinephrine, which would worsen local vasoconstriction and subsequent necrosis, may be administered for analgesic properties, along with systemic analgesia. Alternatively, a local nerve block can be administered, which allows for wound exploration. The pain is usually excruciating and not proportional

to a laceration of similar proportions without envenomation.^{2,12} If the patient is experiencing muscle spasms, intravenous calcium gluconate may be administered. The spine of a stingray is radiopaque; therefore, radiographs should be obtained to determine whether retained parts are present. Ultrasonography may also be helpful.


The most common bacteria implicated in infection as a result of marine animal wounds are *Staphylococcus aureus* and *Streptococcus pyogenes*, most likely originating from host flora.²¹ Sea water presents unique bacterial flora, especially *Vibrio* species, which comprises 57% of the bacterial colony cultures from sea water in 1 study.⁴ Potamotrygon motoro stingray mucus contains pathogenic multiresistant bacteria.²² Prophylactic antibiotics are indicated in patients who are immunocompromised, have residual foreign bodies, or have sustained deep wounds. Antibiotic selection is typically doxycycline, ciprofloxacin, co-trimoxazole, or tetracycline.^{2,15}

Operative intervention is warranted in the initial stages to remove foreign bodies or manage large wounds, which are sometimes extensive due to the serrated spine and its cutting action. Injuries may also breach a joint capsule or cause a neurovascular injury, requiring operative exploration.¹⁵ In cases of established infection, the patient should undergo further irrigation, exploration, debridement, and foreign tissue removal. Magnetic resonance imaging may be helpful in established cases of infection to locate retained foreign bodies in soft tissue, gas pockets, or abscesses.

Currently, no stingray antivenin is available.²³ However, case reports have been published that have shown the benefits of the application of topical recombinant human platelet-derived growth factor-BB and hyperbaric oxygen.^{24,25} Cryotherapy has deleterious results, and no proven role exists for antihistamines or steroids. The application of a cut surface of a bulb of onion has decreased pain and possibly inhibited infection.²⁶

The best way to avoid the sequelae of a stingray injury is injury prevention. As individuals enter the stingray habitat, caution must be exercised in crossing the seabed and not swimming too closely. Stingrays can be easily startled by people swimming directly over them, which should be avoided. As individuals spend more time exploring the seas and oceans, often venturing to more isolated areas, the incidence of injuries can be expected to increase, with a greater potential for adverse outcomes the farther individuals travel from health care facilities.

CONCLUSION

Almost 2000 stingray injuries are reported in the United States every year. These injuries are usually nonfatal and generally cause soft tissue injuries. However, the venom has a unique enzymatic composition resulting in a distinct injury pattern, including tissue necrosis and delayed healing responses. The bacterial flora found in the environment of the stingray adds to the risk of subsequent wound infections. This article describes the protracted course of infection that can ensue following a stingray injury and special considerations, such as searching for retained foreign bodies and the management of the more serious systemic sequelae. 

REFERENCES

- Diaz JH. The evaluation, management, and prevention of stingray injuries in travelers. *J Travel Med.* 2008; 15(2):102-109.
- Evans RJ, Davies RS. Stingray injury. *J Acad Emerg Med.* 1996; 13(3):224-225.
- Perkins RA, Morgan SS. Poisoning, envenomation, and trauma from marine creatures. *Am Fam Physician.* 2004; 69(4):885-890.
- Weiss BF, Wolfenden HD. Survivor of a stingray injury to the heart. *Med J Aust.* 2001; 175(1):33-34.
- Agnew PS, Borden EL. Pedal envenomation by a stingray. A case report. *J Am Podiatr Med Assoc.* 1987; 77(10):559-561.
- Cook MD, Matteucci MJ, Lall R, Ly BT. Stingray envenomation. *J Emerg Med.* 2006; 30(3):345-347.
- Enad JG, Espiritu JM, Fisher D. Stingray injury of the hand: review of management. *Trop Doct.* 2001; 31(3):174-175.
- Forrester MB. Pattern of stingray injuries reported to Texas poison control centers from 1998 to 2004. *Hum Exp Toxicol.* 2005; 24(12):639-642.
- Isbister GK. Venomous fish stings in tropical northern Australia. *Am J Emerg Med.* 2001; 19(7):561-565.
- Smarrito S, Smarrito F, Leclair O, Labbe JL. Surgical management of stingray injuries. About two clinical cases [in French]. *Ann Chir Plast Esthet.* 2004; 49(4):383-386.
- Pedroso CM, Jared C, Charvet-Almeida P, et al. Morphological characterization of the venom secretory epidermal cells in the stinger of marine and freshwater stingrays [published online ahead of print June 23, 2007]. *Toxicon.* 2007; 50(5):688-697.
- Russell FE. Stingray injuries. *Public Health Rep.* 1959; 74(10):855-859.
- Edmonds C, Lowry C, Pennefather J. *Diving and Subaquatic Medicine.* 3rd ed. Oxford, United Kingdom: Butterworth and Heine-mann; 1992.
- Strickland GT, ed. *Hunter's Tropical Medicine and Emerging Infectious Diseases.* 8th ed. Philadelphia, PA: WB Saunders; 2000.
- Lim YL, Kumarasinghe SP. Cutaneous injuries from marine animals. *Singapore Med J.* 2007; 48(1):e25-e28.
- Barss P. Wound necrosis caused by the venom of stingrays. Pathological findings and surgical management. *Med J Aust.* 1984; 141(12-13):854-855.
- Clark RF, Girard RH, Rao D, Ly BT, Davis DP. Stingray envenomation: a retrospective review of clinical presentation and treatment in 119 cases [published online ahead of print May 30, 2007]. *J Emerg Med.* 2007; 33(1):33-37.
- Haddad V Jr, Neto DG, de Paula Neto JB, de Luna Marques FP, Barbaro KC. Freshwater stingrays: study of epidemiologic, clinic and therapeutic aspects based on 84 envenomings in humans and some enzymatic activities of the venom. *Toxicon.* 2004; 43(3):287-294.
- Barber GR, Swygert JS. Necrotizing fasciitis due to *Photobacterium damsela* in a man lashed by a stingray. *N Engl J Med.* 2000; 342(11):824.
- Germain M, Smith KJ, Skelton H. The cutaneous cellular infiltrate to stingray envenomization contains increased TIA+ cells. *Br J Dermatol.* 2000; 143(5):1074-1077.
- Auerbach PS. *A Medical Guide to Hazardous Marine Life.* 3rd ed. Flagstaff, AZ: Best Publishing; 1997.
- Domingos MO, Franzolin MR, dos Anjos MT, et al. The influence of environmental bacteria in freshwater stingray wound-healing [published online ahead of print May 25, 2011]. *Toxicon.* 2011; 58(2):147-153.
- Yarborough JR. Freshwater creatures. *Alert Diver.* 2000; July/August:40-47.
- Auerbach PS, Yajko DM, Nassos PS, et al. Bacteriology of the marine environment: implications for clinical therapy. *Ann Emerg Med.* 1987; 16(6):643-649.
- Rocca AF, Moran EA, Lippert FG III. Hyperbaric oxygen therapy in the treatment of soft tissue necrosis resulting from a stingray puncture. *Foot Ankle Int.* 2001; 22(4):318-323.
- Auerbach PS. *Wilderness Medicine.* 5th ed. Philadelphia, PA: Mosby-Elsevier, 2007.