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Selected Topics: Toxicology

A PROSPECTIVE STUDY OF STINGRAY INJURY AND ENVENOMATION OUTCOMES

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☐ **Abstract—Background: Stingray injuries result in thousands of emergency department visits annually. Objectives: This study aimed to assess the complication rate and outcome of field treatment with hot water immersion. Methods: This was an on-site, prospective, observational study. Subjects were enrolled after having been stung by a stingray. A trained researcher obtained the following information: age, sex, health conditions and medications, and wound description. The efficacy of hot water immersion on pain was recorded. Patients were contacted on postinjury days 3, 7, and 14 for follow up. Results: Twenty-two subjects were included. No obvious foreign bodies were observed in wounds. Ten subjects were treated with hot water immersion and povidone-iodine, 12 with hot water immersion alone. Ongoing symptoms or complications were noted at the 3-day follow-up in 6 of 22 subjects (27.3%). One subject was diagnosed with cellulitis on post-sting day 8 and was treated with antibiotics. Ongoing symptoms or complications were reported more commonly in patients treated with hot water and povidone-iodine compared with those treated with hot water alone ($p = 0.056$). There was a significant difference in wound size between those with and without ongoing symptoms at the 3-day follow-up ($p = 0.0102$). No wounds <1 cm developed any complications. Average duration of water immersion was 73.6 min (range 35–145 min). The mean pain score pretreatment was 7.36 and posttreatment was 2.18, with an average decrease of 5.18 (95% confidence interval 4.22–6.15). Conclusion: Stingray injuries responded well to hot water immersion for pain control. Skin and soft tissue infection was diagnosed in 1 of 22 patients (4.55%).**

☐ **Keywords—marine envenomation; stingray**

INTRODUCTION

Stingray injuries are implicated in thousands of emergency department visits annually in the United States, and are a major source of marine vertebrate-inflicted injury. A stingray's tail possesses a serrated barb, and inadvertent human contact can cause it to whip its tail in defense, causing either a laceration or puncture wound to the victim. Penetration by this barb may result in a glandular secretion of venom (1). Although most of these wounds result in a superficial tissue injury, there have been cases of wounds to certain anatomic areas that have led to complications such as arterial bleeding and spinal cord injury (1). Envenomation occurs in as many as 75% of cases in which the victim is stung (2). The venom contains several components, including serotonin, 5-nucleotidase, and phosphodiesterase. The serotonergic component of the venom is associated with the excruciating pain experienced by the victim after envenomation, and the 5-nucleotidase and phosphodiesterase serve to enzymatically degrade local tissue (3). Envenomations can result in systemic symptoms, including nausea, vomiting, diarrhea, muscle damage, cardiac dysrhythmias,

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hypotension, seizures, and rarely death (4). Fragments of the spine can be embedded within the injury site leading to soft tissue infections and poor healing (4,5).

The current treatment of stingray envenomation involves irrigation and immersion of the wound in hot saline or fresh water heated to 43°C to 46°C (109°–115°F), which is thought to denature the heat-labile venom and provide relief in patients (4). Aside from the venom effects, the victim may also be exposed to numerous pathogenic microbes including Vibrio, Streptococcus, Staphylococcus, Aeromonas, and Clostridium species via the barb and surrounding aquatic environment. Multiple case reports have suggested that a significant number of people who presented to emergency departments or clinics with a stingray injury returned with infection when not treated with prophylactic antibiotics (2–4,6,7). However, prophylactic antibiotics after stingray exposure remains controversial because other studies suggest that the wounds are minor and antibiotics unnecessary (2). Some suggest that antibiotic prophylaxis is currently only recommended for deep penetrating wounds, wounds with significant foreign bodies, or for those victims who are immunocompromised (8).

Previous studies at this time are limited because of their retrospective nature in a health care setting. In our experience, many cases of stingray envenomation may not be seen by a health care provider. The objective of this study was to prospectively analyze and characterize on-site stingray envenomations and effects, examine the utility of hot water immersion, and detail the natural history of these injuries.

METHODS

Patients

We performed an on-site, prospective, observational study of consented beachgoers who presented to lifeguard stations with stingray injuries at a local Southern California beach from May 2015 to August 2016. Subjects of all ages were eligible for enrollment, with subjects <18 years of age entered only with parental consent. A trained researcher stationed at the beach would enroll patients and collect the following survey data from each subject: age, sex, descriptive characteristics of injury, presence or absence of obvious foreign body, health conditions, and medications. Because of the frequency of stingray stings at our beaches, the standard practice of lifeguards at these sites is to treat obvious stings on site with hot water immersion of the affected extremity. Some lifeguards at their own discretion will also apply 10% povidone-iodine wipes to the sting area. Characteristics of water immersion in each case were recorded. The duration of hot water immersion and pain score measured on an 11-item numeric rating scale from 0 to 10 before and after treatment was recorded. Subjects were contacted via telephone survey on postinjury days 3, 7, and 14 to assess pain score and any ongoing symptoms, treatments, or complications of their injury.

Statistical Analysis

Student's *t*-test (paired and unpaired), Pearson correlation coefficient, and either chi-squared or Fisher's exact tests were calculated for the appropriate variables. All statistical analysis was performed using SPSS software (IBM Corporation, Armonk, NY). This study was approved by our Human Research Protection Program.

RESULTS

The study group was comprised of 22 patients (n = 17 males) with a mean age of 29.7 years (range 17–55 years). Table 1 shows the breakdown of study group demographics. No subjects reported a significant medical history of immunocompromised state, vascular insufficiency, or the use of prescription antibiotics or medications. All injuries occurred to a lower extremity. Wound locations were distributed in the following regions of the lower extremity: plantar foot (n = 8), first digit (n = 7), medial foot (n = 3), ankle (n = 3), and lateral foot (n = 1). None of the wounds were initially determined by visual or tactile inspection to contain a retained spine or other foreign body. Mean wound size measured along the longest skin plane axis was 8.6 mm (range 2–20 mm). Details of wound descriptions are outlined in Table 2.

Ten patients were treated with hot water and 10% povidone-iodine wipes, while 12 patients were treated with hot water alone, done at the discretion of the lifeguards and not randomly assorted. The average duration of water submersion was 73.6 min (range 35–145 min). The pain score was significantly improved in each case upon hot water submersion treatment. The average pain score pretreatment was 7.36, and the average pain score

Table 1. Breakdown of Subject Group Demographics

Demographics	N = 22
Gender, n	
Male	17
Female	5
Age in years, n	
<18	1
18–24	9
25–34	7
35–44	1
45–54	3
≥55	1

Table 2. Characteristics of Wounds Seen in Study Group

Wound Description	N = 22
Type, n	
Penetration	12
Laceration	10
Size in cm, n	
<0.3	4
0.4–0.6	4
0.7–0.9	4
1.0–1.5	7
1.6–2.0	3
Location	
Medial foot	6
Lateral foot	1
Plantar aspect of foot	8
Great toe	5
Posterior ankle	2
Treatment	
Hot water	12
Hot water plus povidone-iodine	10

posttreatment was 2.18, for an average decrease in pain score of 5.18 (95% confidence interval 4.22–6.15).

No patients were lost to follow-up. Six subjects (27.3%) reported new or ongoing symptoms at day 3. A summary of these outcomes is presented in Table 3. The subjects' symptoms included mild pain, redness, swelling, and itchiness that all resolved with conservative treatment by day 7 and remained absent on day 14 in all but 1 patient. This subject was a 41-year-old man who had a 1-cm wound to his medial ankle. He was diagnosed with soft tissue infection on day 8 after presenting to his primary care physician with worsening pain, edema, erythema with associated purulent discharge, and vesicle formation. He was treated with intramuscular ceftriaxone injection, followed by a 10-day course of doxycycline and antihistamine with complete resolution of signs and symptoms.

There was a significant difference in reported symptoms and complications at the 3-day follow-up regarding wound size. No wounds <1 cm had new or ongoing effects in follow-up surveys ($p = 0.0102$ using t-test comparison). This significance was further confirmed using a linear discriminate analysis ($p = 0.010$). This statistically significant difference was not seen on day 7 and beyond.

There was a trend, though non–statistically significant ($p = 0.056$), using the chi-squared test performed between the presence of ongoing symptoms or complications at the 3-day follow-up between hot water and hot water/povidone-iodine treatment groups. Five of 10 patients that received povidone-iodine plus hot water experienced some ongoing effect or complication versus 1 of 12 patients treated with hot water alone. There was no significant difference ($p = 0.221$) in presence of complications at the 3-day follow-up between wound types ($p = 0.221$), gender ($p = 0.678$), duration of therapy ($p = 0.6324$), or age ($p = 0.907$).

DISCUSSION

Few studies have prospectively evaluated the natural course of stingray injuries. A chart review study by Clark et al. showed that 17% of patients presenting to the emergency department who did not receive antibiotic prophylaxis later returned with infection versus only 1.4% of patients who did receive antibiotic prophylaxis (4). The actual infection rate of all stingray stings of our study, 4.5%, appears to be lower than this previously reported retrospective acute care facility case series (4). The majority of stingray injuries seen in our study were managed successfully with initial hot water immersion and conservative home care alone. However, our study population was composed of a healthy population, predominantly young and male, without any significant comorbidities.

We did find a correlation between wound size and new or ongoing effects at the 3-day follow-up, but not at day 7. No wounds <1 cm developed any apparent ongoing effects or complications.

Our study suggests that hot water immersion is a useful treatment modality for pain control for stingray stings, with rapid reduction in pain scores after a relatively short immersion period. Future studies are needed to determine whether the addition of povidone-iodine to the water immersion is useful or potentially harmful. Our results showed a higher percentage of complications or ongoing symptoms in those treated with povidone-iodine, although this was not statistically significant. This may be consistent with similar findings of studies detailing

Table 3. Summary of Outcomes of Subjects with Ongoing Complications

Complication	Wound Size, cm	Wound Type	Location	Povidone-Iodine Use
Erythema and pruritus at day 3	2	Laceration	Great toe	Yes
Numbness and swelling at day 3	1	Laceration	Great toe	No
Tenderness and swelling at day 3	1	Laceration	Great toe	Yes
Pain and erythema at day 3	2	Laceration	Plantar foot	Yes
Pain, erythema, and swelling at day 3; pain, swelling, and pruritus at day 7; cellulitis with pustule	1	Penetration	Medial foot	Yes
Tenderness and swelling at day 3	1	Penetration	Great toe	Yes

delayed wound healing in wounds treated with iodine, although other studies contradict this finding (9,10).

Limitations

One of the limitations of this study is that the sample size was small. Also, stingray injuries in this study were presumed. There was not direct identification of the stingray in most of these injuries, which is often the case. The wound pattern and effects were consistent with stingray injury and envenomation in our geographic location. The predominant stingray species in our area is *Urobatis halleri*; however, there are 6 species in the area that are capable of stinging (4). The results of this study are not necessarily applicable to other geographic areas with different species composition.

CONCLUSIONS

In summary, most stingray injuries in this relatively young and healthy population had good outcomes with hot water immersion and conservative treatment. The only factor found to cause a significant increase in risk for complications at the 3-day follow-up was the size of the initial insult. Thus, clinicians and on-site health professionals may use their clinical judgment and consider wound size and appearance, presence of a foreign body, and patient comorbidities to determine use of empiric antibiotic prophylaxis. Further studies are needed to determine the utility of supplemental povidone-iodine.

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ARTICLE SUMMARY

1. Why is this topic important?

There is currently little literature on the natural history of stingray injuries, and even fewer studies look at these injuries from a prospective viewpoint. Previous retrospective research by our institution revealed that persons presenting to the emergency department with a stingray injury had a high rate of infection if not treated with prophylactic antibiotics.

2. What does this study attempt to show?

This article investigates stingray injuries from a prospective viewpoint, examines current treatments, and attempts to define the natural course of these injuries.

3. What are the key findings?

We show that stingray injuries respond well to hot water treatment and do not have as high of an infection rate as previously thought when adequately treated at the scene of the injury.

4. How is patient care impacted?

Stingray injuries should continue to be treated with hot water, and when adequately treated at the scene likely will heal quickly without complications and will likely not require antibiotics.