Cookiecutter Shark-Related Injuries: A New Threat to Swimming Across the Ka‘iwi Channel

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Abstract

In a 5-month period in 2019, 3 long-distance swimmers sustained cookiecutter shark-related injuries while attempting to cross the Ka‘iwi Channel between the Hawaiian Islands of O‘ahu and Moloka‘i. This report is the first case series of cookiecutter shark bites on live humans. A retrospective review of the State of Hawai‘i Division of Aquatic Resources Shark Incidents List was conducted between March 1, 2019, and July 31, 2019. Trauma registry data and medical records were reviewed in patients treated for cookiecutter shark bites at The Queen’s Medical Center in Honolulu, Hawai‘i. All 3 patients sustained nonfatal cookiecutter shark bite circular wounds measuring between 8–13 cm in diameter. They were injured swimming over waters with depths of greater than 2000 feet at night. Patients had prolonged transport times to the emergency department (ED), averaging 73 minutes, due to their injuries occurring on the open water. All were hemodynamically stable upon ED arrival and did not require blood products. Tetanus toxoid was updated, and prophylactic antibiotic coverage, including doxycycline for Vibrio spp., was administered. Two of 3 patients were treated with operative management. Open water swimmers crossing the deep waters between the Hawaiian Islands at night are most at risk for cookiecutter shark bites. Wounds may penetrate down to and through the fascial level. Immediate life-saving hemorrhage control administered by personnel accompanying the swimmers on the open water is important for preventing morbidity and mortality. Antibiotic prophylaxis for marine bacteria is recommended.

Keywords

Hawai‘i, shark, bite

Abbreviations and Acronyms

ABI = ankle-brachial index
CDC = Centers for Disease Control and Prevention
CK = creatinine kinase
DAR = Division of Aquatic Resources
DLNR = Department of Land and Natural Resources
ED = emergency department
EMS = Emergency Medical Services
OR = operating room
PCP = primary care provider
PO = oral
POD = postoperative day
QMC = The Queen’s Medical Center
SIT = Shark-Induced Trauma
Td = tetanus-diphtheria
Tdap = tetanus, diphtheria, and pertussis

Background

Cookiecutter sharks (*Isistius* spp.) are best known for their unique bite and feeding habits that leave a distinctive shallow, smooth, circular, concave wound resembling the cut-out of a cookie cutter. These small, elusive, nocturnal predators are known to feed on a variety of prey, including sharks, whales, rays, sea turtles, and other large pelagic species. Nearly all prior reports of human injuries attributed to the cookiecutter shark have described characteristic wounds on corpses found in the open ocean off the coasts of Comoros, Tanzania, Japan, and Kaua‘i, Hawai‘i.[1–4] In March 2009, the first documented attack on a live human involved an adult long-distance swimmer attempting to cross the ‘Alenuihāhā Channel between the Hawaiian Islands of Hawai‘i and Maui at night.[5] Ten years later, 3 long-distance open ocean swimmers sustained cookiecutter shark bites while attempting to cross the Ka‘iwi Channel between the Hawaiian Islands of O‘ahu and Moloka‘i over 5 months in 2019. This case series describes the unique injuries sustained from the cookiecutter shark, the unique circumstances of these injuries, and subsequent treatment.

Methods

A prior 10-year retrospective review of the State of Hawai‘i Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR) Shark Incidents List identified an unusual series of 3 cookiecutter shark-related injuries between March and July 2019.[6] After institutional review board approval, all data associated with these cookiecutter shark cases in the Shark Incidents List were reviewed, including date and time, location, victim’s activity, water depth, treatment facility, injury description, shark species, and shark size. All patients presented to The Queen’s Medical Center (QMC) in Honolulu, Hawai‘i, a Level 1 trauma center. Trauma registry data and medical records were reviewed retrospectively for clinical data, including patient demographics, treatment provided, and patient outcomes.

Results

Case 1: A male, domestic, non-Hawai‘i resident in his 50s with no significant past medical history was swimming the Ka‘iwi Channel when he suddenly felt pain in his lower abdomen around 3:30 AM, approximately 9.5 hours into his swim. Initial thoughts were that he suffered a jellyfish sting; however, when pulled out of the water by the escort kayak, they noted a

circular bleeding wound just below his umbilicus. The incident occurred approximately 12 miles east-southeast of Koko Head in clear water over 2000 feet in depth (Figure 1). The length of the cookiecutter shark was unknown. Pressure was applied to the wound with a towel, and Emergency Medical Services (EMS) was notified. The patient was brought to shore and then transported by ambulance to QMC, arriving approximately 1 hour and 5 minutes after the bite occurred.

On arrival in the emergency department (ED), his vital signs were within normal limits. Focused Assessment with Sonography for Trauma (FAST) exam was negative for intraperitoneal fluid. Labs were only notable for leukocytosis to 12.57 $x10^3$/mL and mild elevation of creatinine kinase (CK) of 828 IU/L. Tetanus-diphtheria (Td) vaccine, intravenous (IV) doxycycline 100 mg, and IV ceftriaxone 2 g were empirically administered. After evaluation by the trauma team, he was taken emergently to the operating room (OR) for exploration of the penetrating abdominal wound and control of bleeding. The 8-cm circular wound went through the skin and subcutaneous tissues, through the rectus muscle and fascia, down to the level of preperitoneal fat with active bleeding from intramuscular vessels (Figure 2). The peritoneal cavity was not violated. Bleeding was controlled with suture ligation and electrocautery, the fascia closed primarily, and skin left open with a wet-to-dry dressing applied. No blood products were administered. He was discharged on postoperative day (POD) 2 with oral (PO) doxycycline 100 mg every 12 hours, PO ciprofloxacin 500 mg every 12 hours, and continued local wound care. Follow-up was arranged with providers near his home for definitive treatment, where he returned 2 days later.

Case 2: A male, domestic, non-Hawai‘i resident in his 20s with no significant past medical history was swimming the Ka‘iwi Channel when he suddenly felt pain in the left posterior shoulder around 1:00 AM, approximately 7 hours into his swim. The incident occurred approximately 12 miles east-southeast of Koko Head, about the same location as the previous case (Figure 1). The length of the cookiecutter shark was estimated at 1 foot based on wound size. The patient received wound care with blood clotting materials on the main boat. Once ashore, he was transported by ambulance to QMC, arriving approximately 1 hour and 24 minutes after injury.

On arrival in the ED, vital signs were within normal limits, and labs were notable for leukocytosis to 16.56 $x10^3$/mL. Due to penicillin allergy, IV clindamycin 600 mg, IV doxycycline 100 mg, and IV ciprofloxacin 400 mg were empirically administered. Tetanus, diphtheria, and pertussis (Tdap) vaccine was updated. On examination by the ED physician, no active bleeding was noted in the 13-cm circular wound with exposed muscle (Figure 3). In the afternoon, a complex wound repair with multiple layer closure was performed in the OR by the consulted plastic surgeon. The patient was discharged POD 1 with five days of PO doxycycline 100 mg twice a day and PO clindamycin 300 mg 4 times a day. He flew home on the day of discharge, instructed to follow up with his primary care provider (PCP).

Case 3: A male international visitor in his 40s with no significant past medical history was swimming the Ka‘iwi Channel when he sustained a cookiecutter shark bite to the left inner thigh around 10:25 PM, approximately 7 hours into his swim. Initially pulled from the water via escort kayak, he was brought to the main boat, where a tourniquet was applied around 10:30 PM. The incident occurred approximately 11 miles east-southeast of Sandy’s Beach in clear water over 2000 feet in depth (Figure 1). The length of the cookiecutter shark is unknown. Once ashore, he was transported by ambulance to QMC, arriving approximately 1 hour and 10 minutes after injury.

On arrival in the ED, vital signs were within normal limits, and labs were notable for leukocytosis to 17.5 $x10^3$/mL. The trauma team evaluated him, and the tourniquet was removed shortly after ED arrival, approximately 1 hour and 12 minutes after application. Td vaccine and IV cefazolin 2 g were administered. An 8 cm circular wound with exposed muscle to the upper inner left thigh without active bleeding was identified (Figure 4). Ankle-brachial index (ABI) was 0.8 and equivalent in bilateral lower extremities such that no further vascular workup was obtained. The wound was irrigated in the ED, and a wet-to-dry dressing was applied. He was discharged from the ED with 10 days of PO doxycycline 100 mg every 12 hours and local wound care instructions. After a wound check 3 days later, he was cleared to return to his home country with instructions to follow up with his PCP.

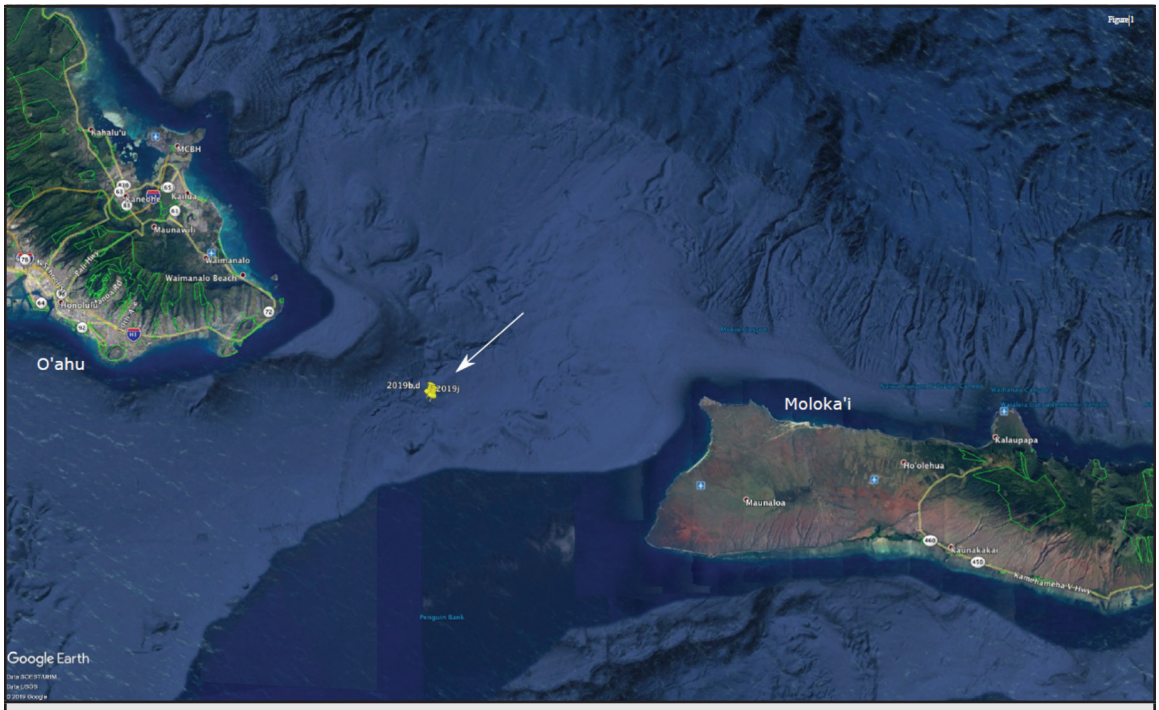

Figure 1. Map showing location of all 3 incidents, noted by thumbtacks with arrow pointing toward them. (Courtesy of the Division of Aquatic Resources, Hawai'i Department of Land and Natural Resources.)

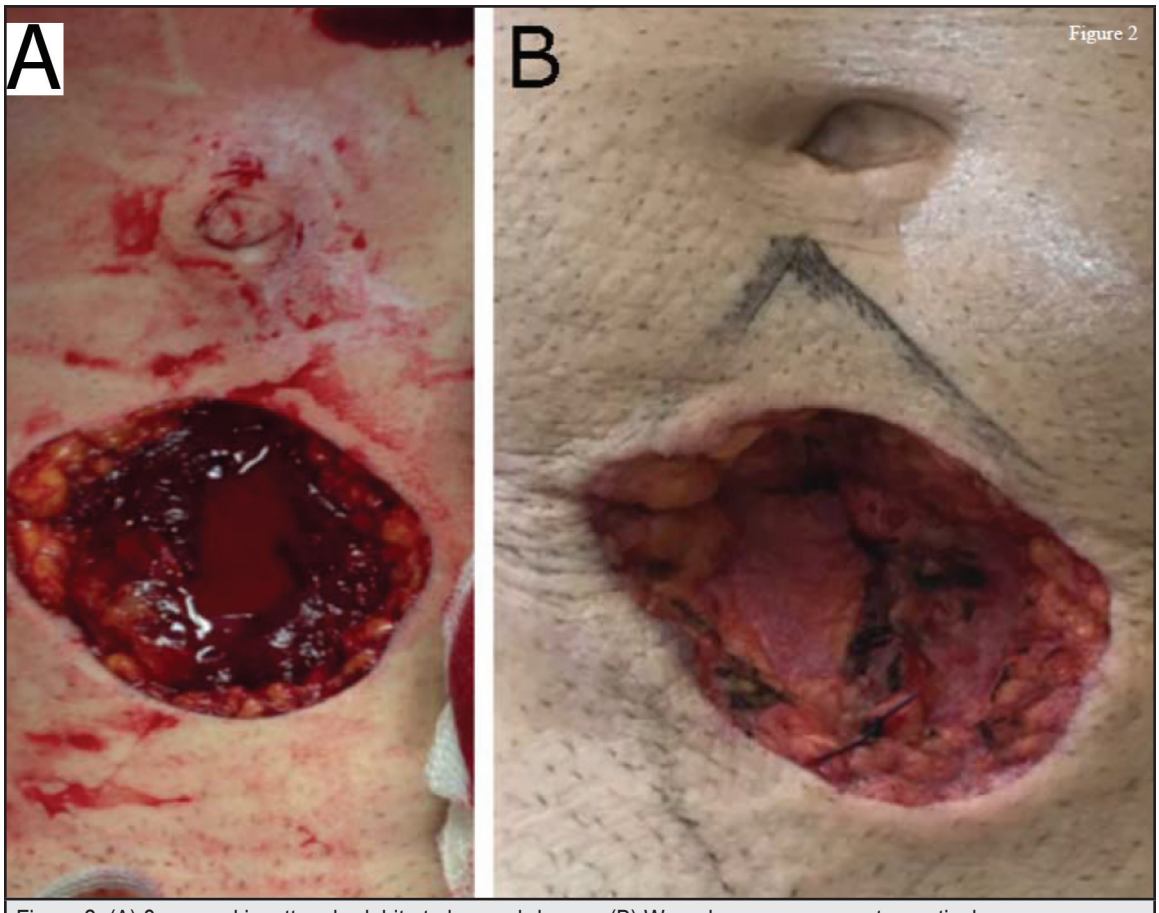

Figure 2. (A) 8-cm cookiecutter shark bite to lower abdomen. (B) Wound appearance postoperatively.

Figure 3. 13-cm cookiecutter shark bite to the posterior left shoulder.

Figure 4. 8-cm cookiecutter shark bite to the inner left thigh.

Figure 5. Stop the Bleed basic principles.[9]

Discussion

This report is the largest published series of cookiecutter shark attacks on live humans and only the second description of such events to date. Ka‘iwi Channel swimmers typically depart from La‘au Point on Moloka‘i between 6:30 PM and 7:30 PM to minimize sun exposure.[7] The timing of this channel crossing coincides with the nocturnal surface feeding activity of the cookiecutter shark. These predators are known to exhibit “hit and run” feeding behavior, taking bites from large pelagic prey while also consuming smaller prey whole. The only other reported case of a cookiecutter shark injury on a live human speculated that boat illumination might have attracted prey, including the purple-back squid, and subsequently, a cookiecutter shark.[5] All 3 victims sustained circular, relatively superficial soft tissue injuries in the middle of the Ka‘iwi Channel in nearly identical locations.

Cookiecutter sharks leave distinctive round or oval scooped-out wounds in their prey, but the exact mechanism of their unique feeding pattern is unknown.[5] The Shark-Induced Trauma (SIT) scale allows for assessment of the injury severity and risk for mortality specific to a shark bite.[8] Factors such as initial blood pressure, location of the injury, debility of the injury, and complexity of the treatment are included in this evaluation. The SIT scores for the 3 incidents are detailed in Table 1. The plug of flesh removed by the cookiecutter shark penetrated through the skin, subcutaneous fat, fascia, and muscle in all 3 cases. Although relatively superficial compared to injuries inflicted by a tiger or great white shark, these wounds remain potentially life-threatening from blood loss and anatomic location of the injury. All patients experienced prolonged times between the time of injury to the first contact with EMS (average 50 minutes) and arrival to the ED (average 1 hour, 13 minutes) due to the remote location of injury on the open ocean. Stop the Bleed techniques for immediate hemorrhage control (Figure 5),[9] including direct pressure and tourniquet were employed by support crew in all cases. These imperative maneuvers may have contributed to the absence of hypotension or the need for blood transfusion on arrival to the ED.

In the specific management of potential infectious complications, *Vibrio* spp. are the most prevalent bacteria in seawater[10] and have previously been cultured from the teeth of a great white shark.[11] *Vibrio* spp. are typically susceptible to doxycycline,[11] and all patients received this as part of their broad-spectrum prophylactic antibiotic regimen against marine bacteria. Guidelines for treating *Vibrio vulnificus* wound infections from the Centers for Disease Control and Prevention (CDC) offer a regimen including doxycycline 100 mg PO/IV twice a day for 7–14 days and a third-generation cephalosporin.[12] Coverage for gram-positive organisms such as *Staphylococcus aureus* and *Streptococcus pyogenes* should also be considered.[10] As there are no clear guidelines for infection prophylaxis, duration and choice of antibiotic regimen after shark injury may vary as observed. Although leukocytosis was present on ED arrival, the wounds did not show evidence of infection and the leukocytosis resolved before discharge in the patients admitted to the hospital. Long-term follow-up was unavailable as all patients returned home after visiting Hawa‘i to swim the Ka‘iwi Channel.

Table 1. Patient Characteristics

	Location of Wound	Size of Wound (cm, in diameter)	SIT Level
Case 1	Infraumbilical region of abdomen	8	3
Case 2	Posterior left shoulder	13	2
Case 3	Inner left thigh	8	2

The Ka‘iwi Channel, also known as the Moloka‘i Channel, is approximately 26 miles of open ocean between the Hawaiian Islands of O‘ahu and Moloka‘i. With a maximum depth approximated at 2300 feet, the combination of wind, strong currents, and large swells make it a popular destination for ocean-based competition. Swimming the Ka‘iwi Channel is a prestigious feat for open water swimmers, with only 5 relay teams and 69 solo swimmers having successfully completed the crossing to date.[13] It ranks among the Ocean’s Seven, a marathon challenge of open ocean swims across the globe, including the English Channel, Catalina Channel, Strait of Gibraltar, North Channel, Cook Strait, and Tsugaru Strait.[14] The abrupt spike in cookiecutter shark-related injuries in the Ka‘iwi Channel is curious not only for its novelty but for the lack of prior cases despite a number of individuals in the water over several decades. A sudden series of attacks by these efficient ocean predators raise the thought of the ‘rogue shark’ theory popularized by the movie *Jaws*.[15] Based on the variation in wounds sustained, however, at least 2 different sharks may have been involved. The sharks may have been drawn in by other prey or may have been responding to sensory cues by the swimmer or support crafts; the exact reasons for these unusual attacks remain unclear. If now conditioned to identify this slow-moving “prey” at the surface, the cookiecutter shark may pose a continued threat and additional level of difficulty to an already daunting challenge. Future cookiecutter shark-related injuries may be anticipated as numerous swimmers tracked in the Ocean’s Seven database have yet to complete the Ka‘iwi Channel.[14]

Conclusion

A typical beachgoer enjoying the sun and warm Hawaiian waters need not worry about an attack from the cookiecutter shark. For experienced open water swimmers crossing deep waters of the Ka‘iwi Channel midway between islands in the dark of night, however, the risk of circular cut-outs of subcutaneous tissue is real. As these injuries occur far from definitive care, immediate life-saving Stop the Bleed equipment and education may be essential for personnel assisting the swimmers on this journey. Wounds may penetrate down to and through the fascial

level depending on the location of injury and individual patient characteristics. Administration of broad-spectrum prophylactic antibiotic coverage, including doxycycline for *Vibrio* spp., and updating tetanus toxoid are recommended.

Conflict of Interest

None of the authors identify a conflict of interest.

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