

## Postmortem wounds caused by cookie-cutter sharks (*Isistius* species): an autopsy case of a drowning victim

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Accepted: 18 July 2014 / Published online: 13 August 2014  
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### Case report

A woman in her late 50s was found deceased and floating in an ocean bay in a temperate region (N31°33'48", E130°33'55") surrounded by wave dissipation blocks. The woman's appearance was orderly, except for her sweater, which was turned up to her face. Her jacket, shoes, and bag were found on a nearby block. The police investigation ascertained that she suffered from depression and had previously contemplated suicide. No suicide note or farewell letters were found. She was last seen alive, by relatives, approximately 6 days earlier.

Medico-legal autopsy revealed several antemortem abrasions and bruises on the head, one of which was accompanied by mild subarachnoid hemorrhages without cerebral contusions on the right parietal lobe. In addition, the victim showed the typical findings of drowning such as ballooning of the lungs (weight: left, 310 g; right, 380 g) with impressions created by the ribs and so-called "Paltauf spots" on the pleural surface, bilateral pleural effusions (left, 160 ml; right, 170 ml), and froth in the airway, despite moderately advanced putrefaction. In the diatom test, marine planktons were detected not only in the digested lungs, but also in the spleen and left kidney.

Toxicological investigations were negative. From all of these findings, the cause of death was determined to be drowning. However, the most notable finding was that circular and elliptical wounds, ranging from soybean-size to  $3.7 \times 5.1$  cm, were found on the exposed (undressed) parts of the body such as the anterior cervical region (Fig. 1) and bilateral antebrachial regions. The edges of these wounds were relatively sharp and were not associated with clear subcutaneous hemorrhages. Their spoon like concave bottom reached the fatty tissue or superficial layer of the muscle.

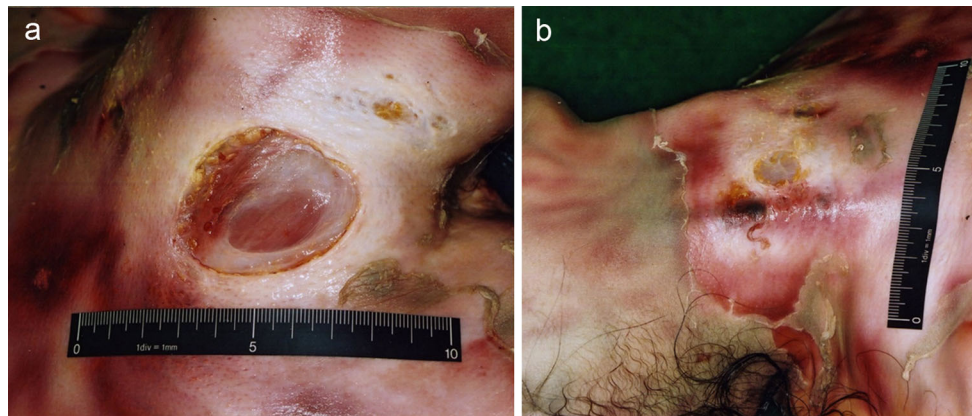
### Discussion

Bodies found floating on the sea may have various types of injuries [1]. Forensic pathologists must distinguish between antemortem and postmortem injuries and accurately interpret their mechanism. Determining the cause of unusual injuries is particularly important. In the present case, unique circular and elliptical wounds without any vital reactions were observed on the exposed (undressed) regions of the victim recovered from the sea.

We suggest that the unique wounds were the post-mortem bite marks of a species of shark belonging to the *Isistius* family (*I. brasiliensis* and/or *I. plutodus*, Fig. 2), which are commonly referred to as "cookie-cutter sharks" because of their extremely unusual feeding behavior [2]. These species are thought to cling onto the surface of their prey (e.g., marine mammals, elasmobranchs, and bony fishes) with thick suction lips (Fig. 3) and a modified pharynx, and then twist or spin as they drive their sharp lower teeth into the victim, producing a characteristic circular and concave wound similar to those observed in this case (Fig. 4). Since they live in colonies, various sized bite

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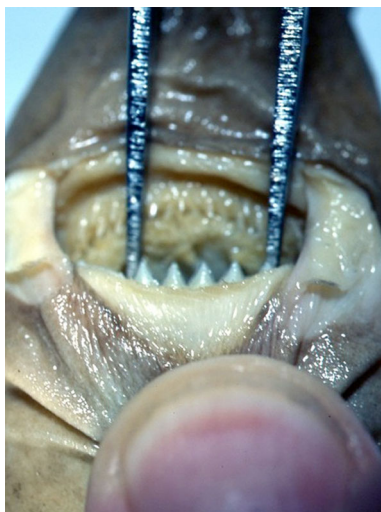
**Fig. 1** Circular and elliptical wounds on the body surface. **a** Left anterior cervical region, 3.7 × 5.1 cm with soybean-size wounds. **b** Right anterior cervical region, soybean-size to broad bean-size



**Fig. 2** An example of *Isistius brasiliensis* (Provided by Tetsuji Miyazaki and Yoko Ihama, Department of Legal Medicine, Graduate School of Medicine, University of the Ryukyus, Japan)



**Fig. 4** Captured fish (*Coryphaena hippurus*) with circular injuries that are similar to the bite marks of *Isistius* species (Provided by Dr. Kazuhiro Nakaya, Professor Emeritus of Hokkaido University, Japan)



**Fig. 3** Thick suction lips and sharp lower teeth of *Isistius brasiliensis* (Provided by Tetsuji Miyazaki and Yoko Ihama, Department of Legal Medicine, Graduate School of Medicine, University of the Ryukyus, Japan)

marks, as observed in our case, are usually left on the surface of the prey (Fig. 3) [2].

*Isistius* species have a small, cylindrical-shaped, gray brownish-colored body and are approximately 50 cm in length (Fig. 2) [2]. They normally inhabit tropical and subtropical oceans (geographic latitude, N20°–S20°; water temperature, 18–26 °C) around the world. Although they remain at depths of at least 1,000 m during the daytime, they migrate to the surface to feed at night. Since they are small and inhabit deep water during the day, there are few reports of an attack by these sharks on humans during normal swimming or diving activities [3], as compared to reports concerning savage and ferocious sharks such as *Carcharodon carcharias*, *Galeocerdo cuvier* (Tiger shark), and *Carcharhinus leucas*, which usually inhabit waters closer to the surface [4].

On the other hand, there have been scattered reports of *Isistius* species interactions with deceased humans. Makino et al. [5] reported a case showing similar circular injuries and C-shaped injuries with a flap on the surface of a body

recovered from the sea off the coast of Okinawa, a subtropical area of Japan. The C-shaped injury was presumed to be an incomplete bite mark. However, although it is a temperate region, this shark has never been seen in the bay where the woman in our case was recovered.

In recent years, we reported similar circular and elliptical wounds on a considerably decomposed body found floating in the same bay as the present case [6]. In that case we concluded that it was likely that the victim had drowned then drifted from a southern subtropical area where the shark is a known inhabitant, because there were differences in species and distribution ratios of plankton between the water of the bay and each organ of the body in the diatom test. However, in the present case, the species and distribution ratios of plankton between the water and each organ were similar. Moreover, the woman's body was kept in the same location by the wave dissipation blocks. Further, a pygmy sperm whale (*Kogia breviceps*) carcass with similar circular and concave wounds had drifted ashore inside the bay (Mr. Nobutaka Kubo, IOWORLD Kagoshima City Aquarium, Japan; personal communication). Accordingly, we suspect that the shark may now inhabit in the bay because of its increased water temperature, caused by global warming ( $+1.21 \pm 0.26$  °C/100 years, [7]).

Although the unusual wounds in our case are considered to be postmortem predation of the cookie-cutter shark, forensic pathologists should be well acquainted with the patterned injuries of antemortem wounds caused by fatal attacks of sharks and other marine animals [8, 9]. Shark attack injuries are usually caused by rows of sharp teeth that are moved in a saw-like motion, leaving deep wounds reaching skeletal muscle or bone [1, 8, 10, 11]. Comparing the serration of bite marks on a victim with the teeth of a shark may enable identification of the species responsible for the attack [12]. Alligators and crocodiles living in rivers and canals may also attack humans [1, 13]. The bite marks show the characteristic pattern of punctures that are paired and get closer to each other as they approach the snout. Moreover, although extremely rare, cases of fatal chest wall penetration injury by the sharp, barbed tail of stingrays [14, 15] and by the sharp bony stings of catfish (wolffish) [16] have been reported. Autopsy examination is crucial in excluding postmortem animal predation, and in assisting in matching patterned injuries to particular animals or species.

Finally, this case suggests that the bite of *Isistius* shark species should be considered as a possible candidate for causing peculiar circular wounds when a body is recovered

from the sea in areas other than tropical and subtropical areas.

**Acknowledgments** We thank Dr. Kazuhiro Nakaya (Professor Emeritus of Hokkaido University, Japan), Tetsuji Miyazaki and Yoko Ihama (Department of Legal Medicine, Graduate School of Medicine, University of the Ryukyus, Japan) for their instruction on the character of the *Isistius* species and for their valuable assistance in providing photographs of the shark.

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