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The assessment of lethal propeller strike injuries in sea mammals

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ABSTRACT

Assessment of injuries in marine mammals may be required to help authorities determine whether human activity was involved. Three cases of marine animal deaths involving propeller blade strikes are reported to demonstrate characteristic features of such cases and diagnostic difficulties that may occur. Case 1: A juvenile New Zealand fur seal (*Arctocephalus forsteri*) suffered two parallel linear incised wounds of the flank and died following small intestinal herniation. Case 2: An Indo-Pacific bottlenose dolphin neonate (*Tursiops aduncus*) died from a deeply incised wound of the left side of the head with shattering of the skull and laceration of the underlying brain.Case 3: An adult female Indo-Pacific bottlenose dolphin (*T. aduncus*) died from two parallel chop wounds to the torso with opening of the thoracic and abdominal cavities with fractures of the ribs and vertebrae. Given that some animals may recover, and that the carcasses of those that are killed may simply not be found or reported, it is impossible to provide an estimate of the incidence of this type of injury amongst wild sea mammals. In cases that do come to forensic attention accurate evaluation of the type of injury may potentially have great medicolegal significance. Post-mortem putrefaction and post-mortem feeding by other sea animals may complicate assessments.

1. Introduction

Injuries from being struck by boat propellers are encountered in both human and animal populations,[1,2] the latter occurring more frequently as increasing numbers of boats either inadvertently or deliberately encroach upon sea mammal territory and/or intentionally approach too closely to facilitate observation. On occasion, forensic pathologists may be requested to examine traumatic lesions in marine mammals to help authorities determine whether human activity was involved, whether the injuries were sustained before or after death, and whether the injuries either caused or played a significant role in the animal's death.[3] Three cases of marine animal deaths involving propeller blade strikes are reported to demonstrate characteristic features of such cases and diagnostic difficulties that may occur in this emerging area of veterinary forensic pathology.[4]

2. Case reports

2.1. Case 1

A juvenile New Zealand fur seal (*Arctocephalus forsteri*) who had been observed swimming and fishing in the sea near a boat launching ramp was noted to have injuries to his flank (Fig. 1). He was captured for assessment and treatment. During transfer, herniation of most of the small intestine occurred through a small lateral abdominal wall defect, followed soon after by death. At necropsy the animal was a normally formed and well nourished juvenile male. No underlying diseases were present that could have caused or contributed to death. Two groupings of parallel injuries were observed on the left side. On the dorsum of the left tail flipper there were two superficial parallel linear wounds measuring approximately 100 mm each, situated 20–30 mm apart (Fig. 2). These extended into subcutaneous tissues and were not associated with underlying fractures. In the left flank two parallel linear incised wounds were found lying approximately 10–20 mm apart. The uppermost wound measured 65 mm and was superficial shelving dorsally into subcutaneous tissues. The lower wound measured 100 mm and was also superficial, except at the lower edge where there was a 20 mm diameter circular defect

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Fig. 1. A juvenile New Zealand fur seal (*Arctocephalus forsteri*) with two parallel propeller strike injuries to the left flank (Case 1).

communicating with the peritoneal cavity through which the majority of the small intestines had herniated (Fig. 3). A floating rib had also been avulsed and was protruding into the wound. The wounds were cleanly incised, linear and in two parallel groupings. There was no evidence of other injury. Death was attributed to small intestinal herniation through an abdominal wall defect most likely caused by a glancing motorboat propeller strike. It is likely that the injury, although deep, had not initially penetrated the abdominal cavity but that rupture had occurred during movement of the animal.

2.2. Case 2

A three-month-old Indo-Pacific bottlenose dolphin neonate (*Tursiops aduncus*) was found dead with an irregular deep laceration of the left side of the head (Fig. 4) with shattering of the skull and facial skeleton and laceration of the underlying brain. There was also a parallel deeply incised wound of the left side of the tail (Fig. 5). Fresh blood clot was present within the wound with bruising of tissues identified histologically. No underlying diseases were present that could have caused or contributed to death. Death was therefore due to craniocerebral trauma most likely from

Fig. 2. The left rear flipper of the New Zealand fur seal showing two superficial parallel linear incised wounds (Case 1).

Fig. 3. The flank of the New Zealand fur seal showing two superficial parallel linear incised wounds with herniation of small intestine through a 20 mm defect (Case 1).

a motorboat propeller strike (details of this case have been published previously).[3]

2.3. Case 3

A well nourished adult female Indo-Pacific bottlenose dolphin (*T. aduncus*) was found dead with numerous injuries which had been distorted by sea lice activity and early putrefactive changes. Three parallel major wounds were identified (Fig. 6). The first consisted of a 96 cm long symmetrical defect running transversely and circumferentially from behind the left ventral flipper across the back, slightly backwards, to terminate at a point behind the right ventral flipper. The defect gaped widely with relatively clean edges and extended through skin, blubber and underlying skeletal muscle with opening of the thoracic and abdominal cavities and exposure of organs (Fig. 7). There were multiple rib fractures with fractures of the mid thoracic vertebrae. The second major wound was situated approximately 49 cm distal, and parallel, to the first wound, approximately 10 cm behind the dorsal fin. It measured 65 cm in length. The third wound consisted of a 13.5 cm defect found 41 cm distal to the second wound at the base of the tail flukes. The last two wounds extended through skin, blubber and skeletal muscle into

Fig. 4. The deeply lacerated cranium of an Indo-Pacific bottlenose dolphin neonate (*Tursiops aduncus*) (Case 2).

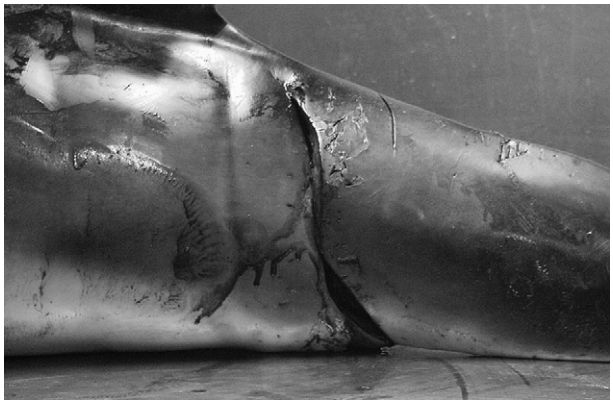

Fig. 5. A cleanly incised wound of the tail of the Indo-Pacific bottlenose dolphin neonate (*Tursiops aduncus*) in Case 2.

Fig. 7. A closer view of the largest wound in Case 3 that extended through skin, blubber and underlying skeletal muscle with opening of the thoracic and abdominal cavities and exposure of internal organs. There were multiple rib fractures with fractures of the mid thoracic vertebrae.

the underlying vertebrae with fracturing. There was associated marked disruption of the thoracic and abdominal cavities with laceration of both domes of the diaphragm and displacement and laceration of the liver and left lung. No underlying diseases were present that could have caused or contributed to death. The size and nature of the wounds was in keeping with chopping from a sizeable propeller blade. If death was due to a propeller strike it would have occurred very quickly given the nature of the wounds and the extent of tissue and organ disruption. The absence of other signs of injury and underlying organic disease would be in keeping with death being caused by the first two wounds, although the possibility of death from another cause with post mortem damage to the animal could not be definitely excluded in this case.

3. Discussion

Motorboat propellers consist of usually unshielded heavy metal blades that rotate at high speed through water. Given their robust construction and rotational energy it is not surprising that they are associated with major injuries. An additional problem is that they may create a current which sucks swimmers (either human or animal) towards the blades.[5] The repetitive nature of propeller rotation means that multiple closely spaced injuries may be sustained with only one impact. Given the requirement for high speed and considerable torque it has been estimated that a three-blade propeller running at 3200 rpm can inflict 160 impacts per second. An alternative way to look at this is that a 33 mm blade can move from the head to the toes in a human in less than 0.1 of a second inflicting approximately 16 blows.[6] While propeller guards have been developed for some craft, they are not widely used.

Lesions that may be found after a propeller strike consist of combined blunt and sharp force injuries with incised wounds,

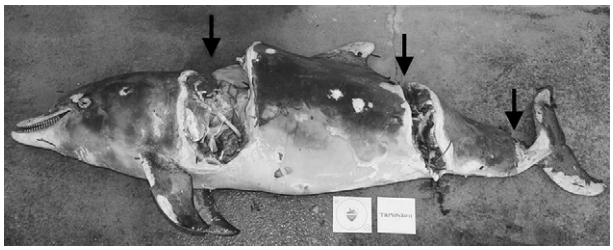

Fig. 6. The putrefied carcass of an adult female Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) showing three parallel chop wounds (arrows) (Case 3).

lacerations and chop wounds, as were seen in the reported cases. The nature of the injuries will depend to some extent on the sharpness of the blade and also on the nature of the boat and the victim. While it has been suggested that most lethal propeller strikes of manatees in Florida, United States, involve larger boats with inboard engines,[2] small propeller injuries have been lethal in humans.[7] A distinguishing feature of these injuries may be their symmetrical and parallel nature.[8] Injuries often consist of significant and mutilating chop wounds with crushing of the skull, vertebrae and skeleton, as was observed in Cases 2 and 3. Amputations and damage to major blood vessels with exsanguination are frequent.[9] The fatality rate of propeller blade strikes amongst humans has been estimated at 15–17%, with a similar rate for major amputations.[6] Delayed death from either sepsis, due to spread of local infection, or starvation, due to an inability to feed, is likely in animals that sustain significant but not immediately life-threatening injuries. For example, permanent neurological deficits have been reported in humans who have survived such injuries,[7] and if present in animals could significantly impair the ability to subsequently successfully forage. Sepsis may be facilitated by contamination of water with raw or treated sewage.[10]

An unusual feature in Case 1 was the delay in intestinal herniation. As was noted, this was most likely due to failure of full thickness penetration of the peritoneal cavity initially, but which eventually occurred some time after the initial injury. Evisceration has certainly been reported in human cases.[6] An emergency first aid measure to consider in victims of propeller strike who have sustained abdominal lacerations/incisions may, therefore, be the application of a pressure dressing to reinforce the abdominal wall until formal assessment and treatment can be undertaken in more controlled circumstances.

The differential diagnosis in animals with similar injuries includes other forms of inflicted injury from humans such as intentional clubbing or stabbing.[11] Given that killing of a marine mammal may be a criminal act in many jurisdictions and may incur a significant penalty, differentiating inflicted from accidental injuries may be extremely important.[12] Similarly, differentiating these injuries from those inflicted by predators such as sharks may also be necessary.[13] Shark bites tend to be paired or single, often with a curved shape that matches the dental arcade of the attacking animal. Shark teeth also tend to leave triangular-shaped wedges of soft tissue with shredding of tissues,[7] and there may be fragments of shark teeth embedded in long bones.[14] While injuries from

propeller strikes are often lacerations (Figs. 4 and 7), due to the significant blunt force involved, cleanly incised edges have been described[13] and were encountered in two of the reported cases due to the sharpness of the impacting propeller blades (Figs. 2, 3 and 5).

A major difficulty that often arises in cases of bodies retrieved from water that is not limited to forensic veterinary practice is in differentiating ante- from post-mortem injuries. Due to the nature of water environments, a body may not be discovered for some time after death, with distortion of tissues by the resultant putrefactive changes and post-mortem predation.[15,16] In Case 2 the presence of clotted blood in the depths of the wounds and histologic evidence of interstitial haemorrhage were both in keeping with antemortem injury. In Case 3 this determination was not as straightforward given the degree of putrefaction that was present.

The reported cases demonstrate features of propeller strikes that may be encountered in marine mammals that include chop wounds, lacerations and incisions. Given that some animals may recover, and that the carcasses of those that are killed may simply not be found or reported, it is impossible to provide an estimate of the incidence of this type of injury amongst wild sea mammals. However as it has been said of humans that "where boating is common, fatal and severe injuries from propellers occur with regularity",[9] it is very likely that the incidence of propeller strikes in sea animals is far higher than is appreciated. Certainly it has been shown that most manatees (*Trichechus manatus*) have scars from being hit by boats.[2] In cases that do come to forensic attention accurate evaluation of the type of injury may potentially have considerable medicolegal significance.

Conflict of interest

None declared.

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Ethical approval

Not required.

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