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Short Note

Computed Tomography Diagnosis of Pneumothorax and Cardiac Foreign Body Secondary to Stingray Injury in a Bottlenose Dolphin (*Tursiops truncatus*)

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Populations of bottlenose dolphins (*Tursiops truncatus*) are known to inhabit and forage in the shallow coastal waters of the southeastern United States year-round (Scott et al., 1996). Dolphin communities along the central west coast of Florida are routinely observed feeding within nearshore seagrass flats less than 2 m in depth (Barros & Wells, 1998). This range overlaps with the known habitat for many stingray species bringing both groups into close proximity. Interactions between dolphins and stingrays are well documented and may occur accidentally as dolphins are foraging or as the result of dolphin play behavior. Additionally, although various fish species are thought to be the primary prey source for these populations, there is evidence suggesting that dolphins may occasionally feed on stingrays (Barros & Wells, 1998; Visser, 1999; Conway & McFee, 2017). Injuries that occur are the result of trauma from the serrated spine located at the stingray's tail base and envenomation from secretory cells located along the ventrolateral grooves of the spine (Figure 1a & b; Pedroso et al., 2007). These injuries range in severity from incidental (McFee et al., 1997; Spanier et al., 2000) to fatal, with eventual outcome being impacted by the physical location of the injury and its chronicity (Walsh et al., 1988; McLellan et al., 1996; Duignan et al., 2000; Wells et al., 2008; McFee & Lipscomb, 2009). This short note describes a fatal stingray interaction with a bottlenose dolphin and the use of computed tomography (CT) imaging for virtual necropsy (virtopsy) for determination of cause of death prior to gross necropsy.

On 17 May 2017, an approximately 6-y-old male bottlenose dolphin (102 kg; 230-cm total length) was found freshly dead, floating near Redington Beach in Pinellas, Florida, and was towed to shore. Stranding biologists from the Clearwater Marine Aquarium Rescue team found the dolphin positioned on his left side with his head facing the surf and his flukes directed toward the beach. This particular dolphin was previously disentangled from crab trap lines in 2011 during which he sustained line injuries resulting in identifiable scarring along the cranial aspect of his dorsal fin and along the commissure of the mandible on both sides. The dolphin was moved to an air-conditioned truck, placed in sternal recumbancy, covered with bagged ice, and transported to the University of Florida for imaging and necropsy.

A CT virtopsy and full *postmortem* examination were performed the following day, 18 May 2017. CT is a non-invasive diagnostic tool that generates cross-sectional, x-ray-based images that can be combined to provide highly detailed, three-dimensional representations of internal anatomy without superimposition of structures. Pulmonary anatomy is best visualized when the lungs are fully inflated and, thus, attempts were made to intubate and insufflate the lungs prior to CT examination. Attempts were discontinued when excessive resistance to insufflation was encountered, and this was subsequently determined to be due to a pneumothorax. A size 12 endotracheal tube was placed in the esophagus for reference. A full body CT exam was performed using a 160-slice multidetector CT machine (Toshiba Prime 160 Multidetector Row CT; Toshiba America Medical Systems, Tustin, CA, USA). Volumetric data acquisition was performed using standard resolution algorithms (slice thickness = 1.0 mm; helical pitch = 0.813; kVp = 120; mAs = 450), and transverse (axial) plane images in bone, lung, and soft

Figure 1. (a) A representative stingray barb from a spotted eagle ray (*Aetobatus narinari*). The external epidermal covering has been removed to reveal the boney spine. Serrations are present along the lateral aspect on both sides of the spine, and the barb base is the site of attachment to the animal. The units of measurement along the left side of the ruler are in cm; and (b) the anatomic location of the barb (black dashed line) along the dorsal mid-line of the tail base in a spotted eagle ray (Photos courtesy of Kim Bassos-Hull, Mote Marine Lab).

tissue windows were available for interpretation. Dorsal (coronal) and sagittal plane images as well as three-dimensional volume-rendering reconstructions were made to help in the interpretation process (Figure 2). Imaging revealed a moderate-to-severe right pneumothorax with a collapsed right lung and the presence of a linear mineral-attenuating foreign body measuring approximately 6.5 cm lodged in the right atrium of the heart. A second linear mineral-attenuating foreign body was identified within the right cervical region of the neck with associated soft tissue swelling. A third linear foreign body was seen within the left dorsal musculature just cranial to the dorsal fin (Figure 3a-c).

Following CT, a full *postmortem* examination was performed. External findings included previously noted scars and epidermal conspecific rake marks. A small 3-mm puncture wound was present in the skin of the right mandible. This wound was associated with a narrow subcutaneous track extending from the puncture wound to the linear foreign body in the cervical area. The linear foreign bodies seen on CT were all identified as individual stingray barbs and later were determined to be from spotted eagle rays (*Aetobatus narinari*) (G. H. Burgess, pers. comm., 17 January 2019). No other external lesions were noted. Internally, a second stingray barb was confirmed within the musculature just cranial and to the left of the dorsal fin. Air-distension of the right thorax was confirmed and consistent with the previously diagnosed pneumothorax. The third stingray barb was identified within the thorax. The proximal aspect of the barb base punctured through the right cranioventromedial lung pleura and is believed to be the cause for the pneumothorax identified on CT. This injury was associated with focal pleuritis. The pointed distal aspect of this barb was directed caudoventrally and penetrated 4.5 cm into the right atrium. No distinct tract indicating the path of the barb's travel was identified. Hematoxylin and eosin stained histological sections of the heart tissues revealed a mild fibrinosuppurative endocarditis with associated hemorrhage as well as perinodal eosinophilic cellulitis. Pneumonia, as well as pleural

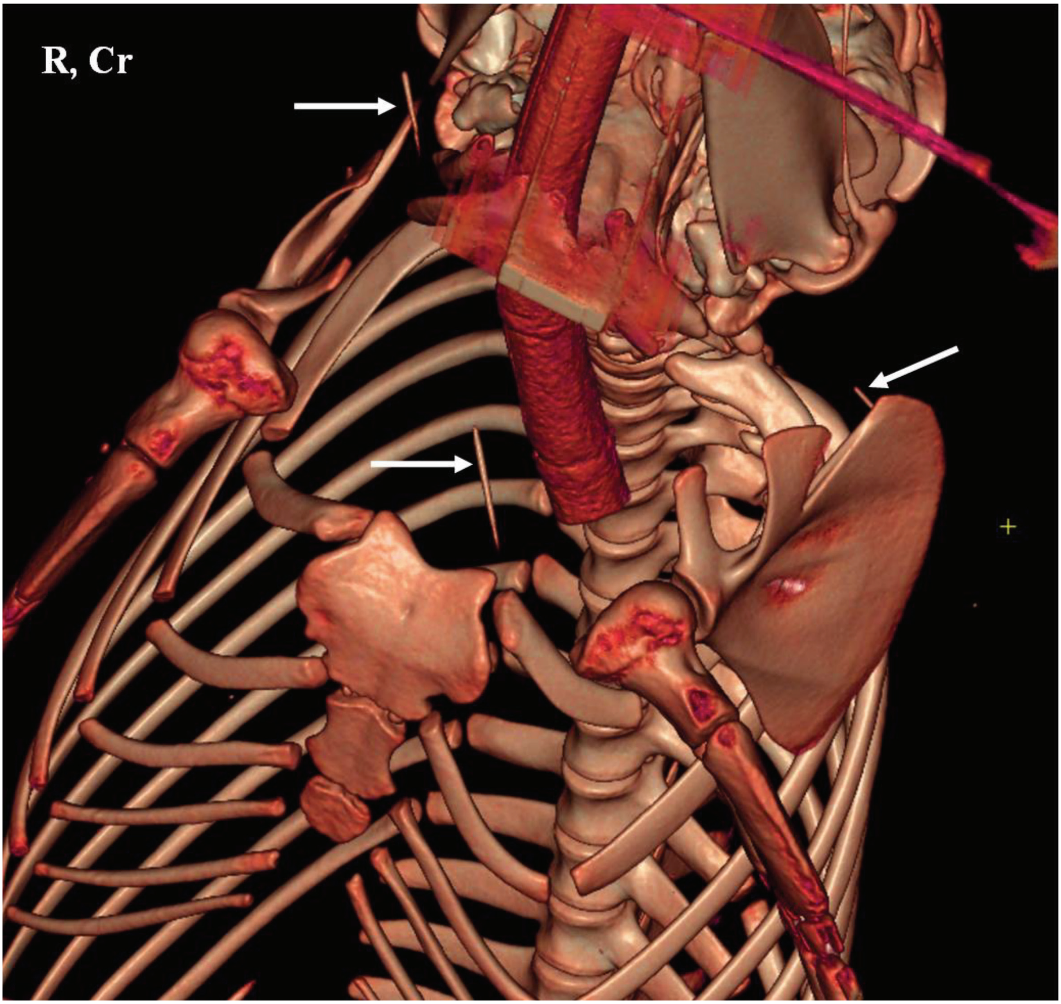

Figure 2. Three-dimensional reconstruction of examined bottlenose dolphin (*Tursiops truncatus*) highlighting the location and spatial relationship of the three stingray barb foreign bodies (indicated by white arrows). Based on their distribution and orientations, they appear to be from three distinct stingray interactions. Gross necropsy confirmed these to be three distinct stingray barbs.

and interstitial fibrosis, was also present, and diffuse follicular lymphoid depletion of lymph nodes was observed. Other histologic findings were considered to be incidental and included nasitremiasis with associated rhinitis. Aerobic culture of heart blood yielded growth of an unidentified gram-negative bacillus species and may represent infection introduced via the penetrating trauma.

The cause of death in this bottlenose dolphin was likely the result of penetrating cardiac trauma and secondary pneumothorax from a stingray barb. The right cervical and left epaxial barbs are believed to be incidental findings that did not directly contribute to death in this individual but may represent a source of chronic inflammation with variable stages of migration. It is not known how long this dolphin survived post-trauma. Routine monitoring of the dolphin population in this area showed that he displayed normal behavior for 6 y post-disentanglement but was spotted about a week prior to his death behaving abnormally. It is possible that this reportedly abnormal behavior correlates with the time of the stingray injury. The lack of a clear path of travel as well as the absence of a puncture wound also seem to suggest a certain chronicity to the injury; however, lack of discernible points of entry or travel have been documented in previous cases (Walsh et al., 1988). Migration of the barb into the heart over a period of time is possible, and the pleuritis associated with the location of the barb

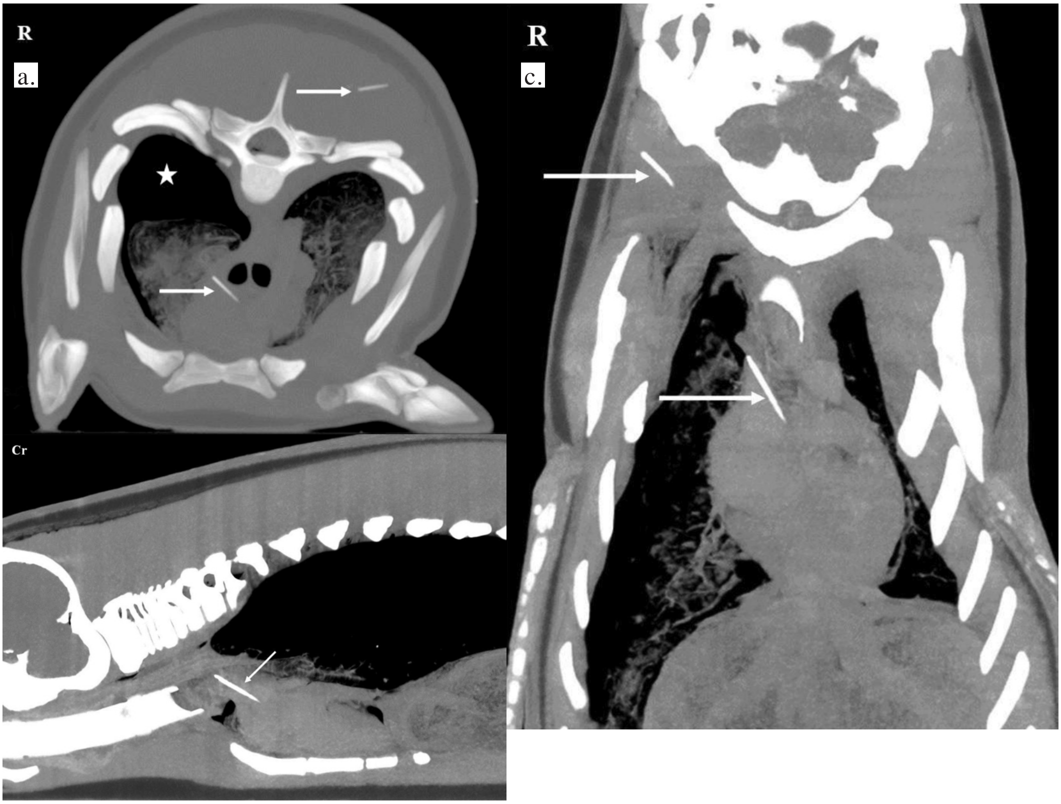

Figure 3. (a) Transverse plane, maximum intensity projection (MIP), and mid-thoracic section highlighting the right-sided pneumothorax (star); a small consolidated right lung is seen within the ventromedial right hemithorax. Two of the mineral-attenuating foreign bodies are also seen within the right atrium of the heart and within the left epaxial musculature (indicated by white arrows); (b) sagittal plane, MIP, cervical section, and mid-thoracic section depicting orthogonal view of the foreign body within the right atrium of the heart; and (c) dorsal plane, MIP, cervical section, and mid-thoracic section showing location of the foreign body within the right atrium of the heart and the foreign body within the right cervical region with associated soft tissue swelling.

base supports the idea that the barb caused frictional trauma to the lung surface prior to inducing a pneumothorax. The fibrinosuppurative inflammation and lymphoid depletion seen histologically would also seem to indicate a more chronic or at least a subacute response. Variable tissue responses to stingray injuries have been observed, however; and the presence of venom within tissues has been noted to impede interpretation of injury chronicity (Halstead & Halstead, 1978). In mice, stingray venom has been determined to cause rapid tissue necrosis and leukocyte recruitment with histological changes evident within hours of envenomation (Kimura et al., 2014). Therefore, although fatal injury in this animal most likely occurred about a week prior to his death, coinciding with the reported abnormal behavior, a definitive time course cannot be concluded.

The use of advanced imaging in this case allowed for a determination of cause of death prior to gross necropsy. Facilitation of CT imaging requires additional time, planning, and personnel. The logistics of animal transportation and cost to an individual facility are added considerations. Compared to standard radiographs, CT is capable of providing highly efficient, detailed, full-body images that can be viewed in multiple anatomic planes. Three-dimensional reconstructions can be generated that highlight specific anatomic and spatial relationships such as the barbs in this case. Other imaging modalities like magnetic resonance imaging (MRI) may provide even greater tissue detail but are generally more expensive and time-intensive than CT. In addition, CT is considered to be the gold standard diagnostic imaging modality for evaluation of the pulmonary parenchyma in veterinary medicine. Thus, unless there is a specific anatomic region of interest, CT imaging is likely a more practical option. CT imaging in this case facilitated the discovery of secondary barb injuries that would not be immediately evident at the time of necropsy. Standard necropsy procedures allow for more generalized examination of certain tissues, such as large muscle groups, and, thus, depending on location, certain injuries or foreign bodies may be missed.

In this bottlenose dolphin, the injuries and their locations suggest multiple, distinct interactions between this dolphin and stingrays. The specific type of interaction cannot be determined; however, the injuries were likely sustained accidentally while hunting or from the deliberate engagement of a stingray. Ingestion of stingray barbs is a less likely hypothesis given the absence of oral, pharyngeal, esophageal, or gastrointestinal trauma. The peripheral location of two of the barbs also seems to reduce this likelihood. The direction of the fatal barb and its path through the lung suggest that ingestion remains a possibility (Obendorf & Presidente, 1978; McLellan et al., 1996). Given the lack of external evidence of penetration of the primary barb, the possible chronic nature of the injuries seen in this case and in others, and the frequency with which dolphins seem to interact with stingrays, CT imaging represents a valuable *postmortem* and potentially *antemortem* screening tool for clinicians working with stranded or rehabilitating wild dolphins. Furthermore, stingray barb injuries should be considered as a differential in cases of dolphin mortalities or strandings, even in the absence of external trauma, and especially in those cases with unexplained clinical signs.

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Literature Cited

Barros, N. B., & Wells, R. S. (1998). Prey and feeding patterns of resident bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. *Journal of Mammalogy*, *79*(3), 1045-1059. https://doi.org/10.2307/1383114

Conway, J. N., & McFee, W. E. (2017). Ingestion of stingrays (*Dasyatis* spp.) by a common bottlenose dolphin (*Tursiops truncatus*). *Aquatic Mammals*, *43*(3), 229-232. https://doi.org/10.1578/AM.43.3.2017.229

Duignan, P. J., Hunter, J. E. B., Visser, I. N., Jones, G. W., & Nutman, A. (2000). Stingray spines: A potential cause of killer whale mortality in New Zealand. *Aquatic Mammals*, *26*(2), 143-147.

Halstead, B. W., & Halstead, L. G. (1978). *Poisonous and venomous marine animals of the world*. Darwin Press.

Kimura, L. F., Prezotto-Neto, J. P., Antoniazzi, M. M., Jared, S. G., Santoro, M. L., & Barbaro, K. C. (2014). Characterization of inflammatory response induced by *Potamotrygon motoro* stingray venom in mice. *Experimental Biology and Medicine (Maywood)*, *239*(5), 601-609. https://doi.org/10.1177/1535370214523704

McFee, W. E., & Lipscomb, T. P. (2009). Major pathologic findings and probable causes of mortality in bottlenose dolphins stranded in South Carolina from 1993 to 2006. *Journal of Wildlife Diseases*, *45*(3), 575-593. https://doi.org/10.7589/0090-3558-45.3.575

McFee, W., Root, H., Friedman, R., & Zolman, E. (1997). A stingray spine in the scapula of a bottlenose dolphin. *Journal of Wildlife Diseases*, *33*(4), 921-924. https://doi.org/10.7589/0090-3558-33.4.921

McLellan, W. A., Thayer, V. G., & Pabst, D. A. (1996). Stingray spine mortality in a bottlenose dolphin, *Tursiops truncatus*, from North Carolina waters. *Journal of the Elisha Mitchell Scientific Society*, *112*(2), 98-101.

Obendorf, D. L., & Presidente, P. J. A. (1978). Foreign body perforation of the esophagus initiating traumatic pericarditis in an Australian fur seal. *Journal of Wildlife Diseases*, *14*(4), 451-454. https://doi.org/10.7589/0090-3558-14.4.451

Pedroso, C. M., Jared, C., Charvet-Almeida, P., Almeida, M. P., Neto, D. G., Lira, M. S., Haddad, V., Jr., Barbaro, K. C., & Antoniazzi, M. M. (2007). Morphological characterization of the venom secretory epidermal cells in the stinger of marine and freshwater stingrays. *Toxicon*, *50*, 688-697. https://doi.org/10.1016/j.toxicon.2007.06.004

Scott, M. D., Wells, R. S., & Irvine, A. B. (1996). Long-term studies of bottlenose dolphins in Florida. *IBI Reports*, *6*, 73-81.

Spanier, E., Goffman, O., Kerem, D., & Lavalli, K. (2000). Injury of an Indian Ocean bottlenose dolphin (*Tursiops aduncus*) in the Red Sea by a stingray spine. *Aquatic Mammals*, *26*(3), 196-201.

Visser, I. (1999). Benthic foraging on stingrays by killer whales (*Orcinus orca*) in New Zealand waters. *Marine Mammal Science*, *15*(1), 220-227. https://doi.org/10.1111/j.1748-7692.1999.tb00793.x

Walsh, M. T., Beusse, D., Bossart, G. D., Young, W. G., Odell, D. K., & Patton, G. W. (1988). Ray encounters as a mortality factor in Atlantic bottlenose dolphins (*Tursiops truncatus*). *Marine Mammal Science*, *4*(2), 154-162. https://doi.org/10.1111/j.1748-7692.1988.tb00195.x

Wells, R. S., Allen, J. B., Hofmann, S., Bassos-Hull, K., Fauquier, D. A., Barros, N. B., DeLynn, R. E., Sutton, G., Socha, V., & Scott, M. D. (2008). Consequences of injuries on survival and reproduction of common bottlenose dolphins (*Tursiops truncatus*) along the west coast of Florida. *Marine Mammal Science*, *24*(4), 774-794. https://doi.org/10.1111/j.1748-7692.2008.00212.x