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Thoracolumbar Kyphoscoliosis and Compression Fracture of a Thoracic Vertebra in a Captive Bottlenose Dolphin *(Tursiops truncatus)*

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Abstract

A captive-born, 7-year-old male bottlenose dolphin (*Tursiops truncatus*) suddenly acquired a dorsal hump at the cranial base of its dorsal fin. Subsequent clinical signs or swimming abnormalities were not observed and one year later it died suddenly. Necropsy revealed chronic cholangiohepatitis and lymphadenitis suggestive of a viral infection, with kyphoscoliosis centered on an old malunion compression fracture of the 12th thoracic vertebra associated with moderate bony proliferation, fusion, and lysis of this and adjacent vertebrae. Possible causes of fractures, particularly conspecific aggression, and the remarkable functional longevity of dolphins with vertebral malformations are discussed.

Key Words: bottlenose dolphin, *Tursiops truncatus*, thoracic vertebrae, fracture, kyphoscoliosis, necropsy

Introduction

Reports of vertebral pathology in dolphins are scattered and frequently derived from osteological collections. These include spondylosis deformans (previously known as spondylitis deformans; Kompanje, 1995a), often with extensive proliferative hyperostosis and ankylosis of adjacent vertebrae, as in harbor porpoises, *Phocoena phocoena* (Kinze, 1986; Kompanje, 1995b; Slijper, 1936); bottlenose dolphins, *Tursiops truncatus*; white-beaked dolphins, *Lagenorhynchus albirostris* (de Smet, 1977; Kompanje, 1995b); and in longfinned pilot whales, *Globicephala melas* (Cowan, 1966). Longfinned pilot whales (Cowan, 1966) and bottlenose dolphins (Alexander et al., 1989; Morton, 1978) also have shown cases of vertebral osteomyelitis, including an unusual case in which bony penetration by the spine of a manta ray caused osteomyelitis of the vertebral arch and body of a lumbar vertebra in a common dolphin, *Delphinus delphis* (Gallo Reynoso & Tovar Aguilar, 1989). Additionally, fractures of vertebrae have been reported in bottlenose and other dolphin species (de Smet, 1977; Loth, 1940; Lydekker, 1903; Simpson & Cornell, 1983; Slijper, 1936; Sweeney, 1990). These acquired vertebral lesions were restricted to the lumbar and caudal regions, with few exceptions, such as the report of congenital spina bifida in the thoracic vertebrae of longfinned pilot whales (Cowan, 1966). Another exceptional case involved vertebral body fracture with kyphosis in a stranded young adult female Risso's dolphin, *Grampus griseus*, in which significant healing callus involved the bodies of the first and second, as well as the fourth and fifth caudal vertebrae (Nutman & Kirk, 1988). Interestingly, both kyphoscoliosis and a fractured thoracic vertebra were present in the bottlenose dolphin of the present study, which describes the history, the postmortem gross anatomic and histopathologic findings, and the skeletal anatomy of an adolescent male, captive-born bottlenose dolphin with sudden onset of kyphoscoliosis and a fractured thoracic vertebra.

Case Report

The dolphin, a 7-year 7-month old, male bottlenose dolphin, was captive-born and raised from wild-caught Gulf of Mexico parents. He was kept with other bottlenose dolphins in a marine mammal park at Gulfport, Mississippi, USA. At 6.5 years of age, a "lump" suddenly appeared on the dorsal aspect of the trunk at the cranial base of the dorsal fin. The dolphin showed no resultant clinical or swimming abnormalities, but one year later the dolphin stopped eating, became depressed, and died within three days. A gross postmortem examination was performed on site, and tissues were collected in formalin and forwarded to the Oklahoma Animal Disease Diagnostic Laboratory in Stillwater, Oklahoma.

Necropsy revealed a dolphin in good body condition with an external dorsal hump. Internally, the liver, pancreas, lymph nodes, and thoracolumbar vertebrae showed significant abnormalities. The liver was large and pale, all lymph nodes were enlarged with pale areas in their parenchyma, the adrenal glands were swollen, and there was 0.5 l of yellow transudate in the peritoneal cavity. Routine microscopic examination of the liver showed portal triads with marked infiltration of lymphocytes and histiocytes and a few nests of similar cells in the lobular parenchyma. Lymph nodes were markedly edematous and infiltrated with histiocytes, many of which contained hemosiderin. One section of the pancreas contained several lymphocytic nodules and one small focus of necrosis containing nuclear remnants; the adrenal gland cortices had foci of hemorrhage. The lungs were inflammation free, and mixed cultures of commensals were isolated from lung tissue and peritoneal fluid. The histopathologic conclusion was chronic cholangiohepatitis, multiple lymphocytic pancreatitis, and chronic lymphadenitis. A definitive cause of death was not established.

The affected region of vertebral column was removed, frozen, and made available for further study. Having taken standard plain-film lateral and dorsoventral radiographs, we then dissected this isolated specimen which contained the nine caudal-most thoracic and first four lumbar vertebrae, and subsequently cleaned the bones by simmering them in water. Because Gulf of Mexico bottlenose dolphins predominantly have 14 thoracic vertebrae (Watson, unpubl. data), we designated the last thoracic in this specimen as T14.

An old malunion compression fracture was present in the body and of the right half of the arch of the 12th thoracic vertebra, with severe displacement dorsally; that is, the cranial aspect of T12 was displaced dorsally relative to caudal aspect of T11. Additionally, the bodies and arches of adjacent vertebrae showed an associated secondary deformation—T11 being more affected than T13. The ventral parts of the bodies of T11 and T12 were almost obliterated; on lateral view, the lesion appeared as a wedge, base dorsally, and the resulting kyphosis of 52°, centered at T12, involved the adjacent four to five vertebrae cranially and caudally (Figure 1). Intervertebral disk spaces adjacent to the lesion were non-uniform in width, especially those cranial to T11. The cranial and caudal epiphyses on the vertebral bodies were not parallel and the disk spaces were wedge shaped. The vertebral bodies of T11 and T12 were more radiopaque than adjacent bodies (suggesting a compression fracture rather than a pathological

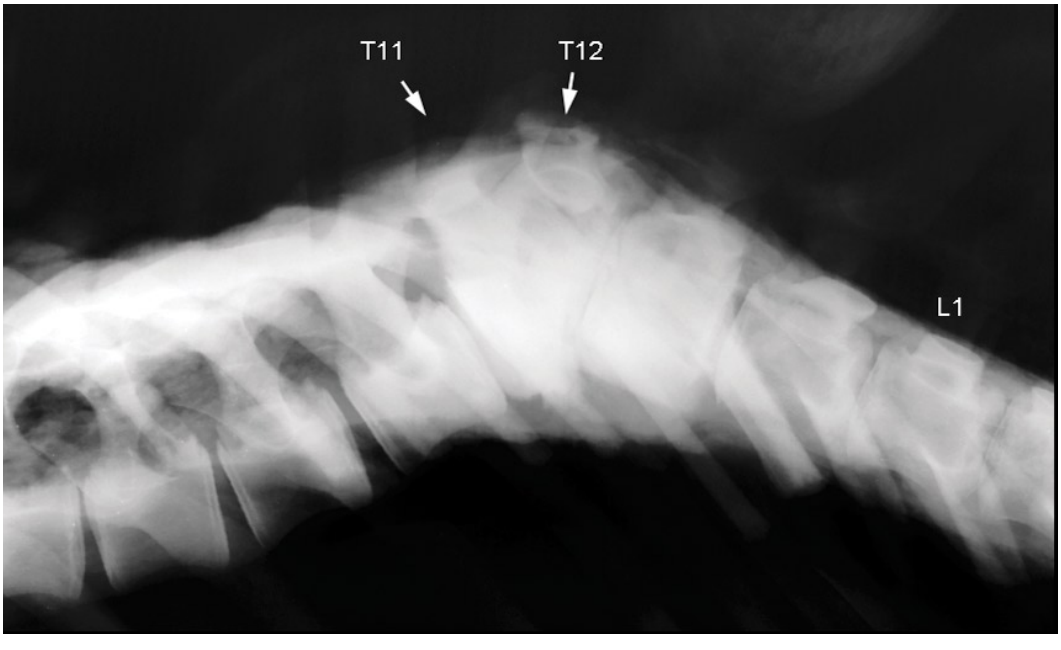

Figure 1. Lateral plain-film radiograph of isolated thoracolumbar junction of bottlenose dolphin demonstrating kyphosis centered on the fractured 12th thoracic vertebra (T12), and an increased radiopacity of the vertebral bodies of T11 and T12; the tall spinous processes are not visible in this view, but the long transverse processes of the 13th and 14th thoracic and first lumbar vertebrae (L1) are seen. The cranial is to the left.

fracture). Additionally, mild to moderate irregular proliferative bony callus formation was present ventral to the T11/12 lesion and laterally at the intervertebral disk level between T11/12 and T12/13. The remaining fragment of the body of T12 was solidly ankylosed dorsally and dorsolaterally on the right side to T11, and little of the intervertebral disc and adjacent vertebral body epiphyses was detected on the cleaned bones. Dorsoventral view revealed a mild scoliosis (10°) at this level, concave to the left.

Discussion

The cause of death in this dolphin could not be determined although histopathologic findings of chronic inflammatory disease in the liver, lymph nodes, and pancreas suggested a chronic viral infection (Ringler, 1997). The cause of the vertebral lesion was likewise undetermined, but radiographically, the considerably malformed and sclerotic vertebral bodies of the 11th and 12th thoracic vertebrae were indicative of a compression fracture. It is possible that the vertebra may have been fractured as a result of conspecific aggression, as the affected dolphin was an adolescent male confined in a pool with others of both sexes and mixed ages. Agonistic behavior is common among dolphins during attempts for mating and during dominance relationships; such behavior entails being rammed by or ramming other dolphins (Reynolds et al., 2000). Moreover, field observations and postmortem examinations have documented the trauma-inducing capability and lethality of bottlenose dolphins' violent interactions with their own calves (Dunn et al., 2002) and harbor porpoises in free-ranging populations (Jepson & Baker, 1998; Ross & Wilson, 1996). In these situations, the majority of animals died from trauma characterized by multiple fractures of the skeleton (particularly multiple ribs), extensive bruising and hemorrhage in the subcutaneous tissues and underlying muscles, and damaged internal organs. These injuries "appeared to be the result of high-energy blunt impact" (Ross & Wilson, 1996, p. 284), and included fractures of the lumbar spinous processes at their bases, perforated lungs, and rupture of the liver. Ruptured and dislocated thoracic intervertebral joints were a common finding.

Other studies of museum specimens revealed occasional fractures of spinal and transverse processes of lumbar vertebrae in bottlenose dolphins (de Smet, 1977; Slijper, 1936), and in the lumbar and caudal regions of other species (Loth, 1940; Slijper, 1936). Caudal vertebral body fractures have been seen in captive bottlenose dolphins (Simpson & Cornell, 1983; Sweeney, 1990) and in a beluga, *Delphinapterus leucas* (Slijper, 1936), but we are not aware of reports of fractured thoracic vertebrae (processes or bodies) in any species of dolphin. Additionally, the frequency of these acquired vertebral lesions is in contrast to the rarity of congenital vertebral malformations in dolphins. Two cases of congenital caudal vertebrae and one of thoracic spina bifida in longfinned pilot whales are reported (Cowan, 1966).

As is evident, the dolphin of the present study lived for 12 months after the initial trauma and apparently was affected little by the vertebral fracture and kyphoscoliosis. Other dolphins have demonstrated remarkable survivability with compromised vertebral columns. For example, a young adult female Risso's dolphin with fractures of two caudal vertebrae survived "several months, but less than one year" (Nutman & Kirk, 1988, p. 92), and also had a pronounced kyphosis centered on a considerable healing callus involving the bodies of the affected vertebrae. Moreover, ten free-ranging dolphins (six bottlenose dolphins; two orcas, *Orcinus orca*; and two Hector's dolphins, *Cephalorhynchus hectori*) have been documented with mild to moderate vertebral column malformations consisting of either scoliosis, kyphosis, or lordosis (Berghan & Visser, 2000). All ten were swimming normally and "appeared to be in good physical health and able to function independent of their malformation" (p. 24); one of these dolphins was observed for eight years. Another case cited in the same study was of a wild-living bottlenose dolphin observed for the past 20 years with scoliosis in the caudal peduncle. Whether fractures of vertebrae or other causes contributed to these axial malformations is unknown. Bony lesions (fractures), however, were associated with the vertebral column deformation in the present case and are reported in others, some of which involved massive ankylosis with pronounced curvature deformations (e.g., in whitebeaked dolphins; Kompanje, 1995b). On the other hand, muscle-related scoliosis (without bony defects) has been reported in captive bottlenose dolphins and pilot whales (Sweeney & Ridgway, 1975), and in all cases resulted in death or elected humane euthanasia.

Clearly, for dolphins swimming in the oceanic environment, the integrity of the vertebral column is vital as the attachment and lever for their massive axial locomotory musculature. Studies, including the present study, have demonstrated that dolphins with significant vertebral malformations can survive for long periods of time, even reaching into adulthood, which underscores an extraordinary ability for functional adaptation to a gross structural deformation.

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