Congenital Scoliosis of a Bottlenose Dolphin

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Abstract: There are many reports of cetaceans with deformed and twisted bodies. Skeletal pathology descriptions have shown changes to axial skeletons because of injury, trauma, or disease. We present a bottlenose dolphin (Tursiops truncatus) that shows characteristic patterns of congenital skeletal deformity, including malformed vertebrae, ribs, and sternum. These malformations were consistent with segmentation and formation defects arising during early embryonic development, with a resulting cascade of deformity and compensatory pathology. In spite of severe deformities, the dolphin lived 18 yr, raised two calves, and likely would have lived longer had she not succumbed to sepsis and the piercing of the aorta caused by a stingray barb.

Key words: Bottlenose dolphin, congenital scoliosis, formation defect, segmentation defect.

Scoliosis has been described from free-ranging cetaceans (Berghan and Visser, 2000), postmortem examination (Watson et al., 2004), and studies of museum collections (Kompanje, 1999). This condition takes two general forms, congenital scoliosis (CS) and idiopathic scoliosis (IS). Congenital scoliosis results from an embryonic developmental abnormality, and IS generally develops from disease or trauma. Although both forms are defined by lateral curvature, they often present as a three-dimensional deformity, including kyphoscoliosis or lordoscoliosis.

In dolphins, scoliotic changes from conspecific aggression (Watson et al., 2004) and muscle damage from strandings (Geraci and St. Aubin, 1987) or improper transport (Spotte et al., 1979), have been associated with trauma. Animals of all ages and both sexes are affected, and because these changes seem to be associated with trauma or disease, all would be considered IS. By contrast, CS results from developmental deformities of the skeleton before birth. Vertebral deformities of CS are characterized as defects in formation, segmentation, or both (Erol et al., 2002). We present a bottlenose dolphin (Tursiops truncatus) showing characteristic malformation of CS with changes to skeletal elements, indicating an early developmental defect leading to progressive deformity.

Sarasota Bay, Florida, has been the site of the longest running study of a wild dolphin population, initiated in 1970, with sighting records of identifiable resident dolphins spanning five generations and four decades. The dolphin MML0535 was a long-term resident of the Sarasota Bay, Florida, dolphin community (Wells, 2003) and was first sighted on 11 September 1989 when it was 2 yr old, with 176 sightings from 1989–2005. Upon this dolphin’s first health assessment on 11 June 1991, at 4 yr old, it showed no obvious signs of deformity. At that time, total body length (TL; straight line measurement from the tip of the rostrum to the fluke notch) of 211 cm was within the reference range for her age and sex class (mean=216 cm, SD=12 cm, n=26). The second time it was examined, during a health assessment was 10 June 2004, her unusual body size was evident. At 215 cm total length, she was well below the reference range length for 17-yr-old females (mean=250 cm, SD=4 cm, n=8). Confirmed sighting records indicated that this dolphin had given birth to two calves, both of which were alive at the time MML0535’s death and have borne calves of their own. Future generations of MML0535’s offspring should be closely monitored for signs of deformity, particularly during the age of rapid growth (2–4 yr of age). Now mature, neither offspring has shown signs of scoliosis. The third gener-
ation calves have yet to be handled for health assessment.

Mote Marine Laboratory retrieves stranded cetaceans, and detailed postmortem examinations, including histopathology, microbiology, and toxicology are performed by the Stranding Investigation Program (SIP). Since 1985, SIP has maintained a cetacean osteologic collection of >650 specimens of 17 species. After necropsy, skeletons are prepared by wet maceration, then dried, and measurements are recorded and stored for future study.

The carcass of MML0535 was found floating in the Manatee River (Bradenton, Florida 27°30′N, 82°32′W), on 9 October 2005, and was examined the same day. At the time of stranding, MML0535 was emaciated and in poor overall body condition (Fig. 1). No signs of anthropogenic impact or interaction were found on the carcass. It measured 214 cm and weighed 117 kg. Cause of death was determined to be the piercing of the aorta caused by a stingray (order Myliobatiformes) barb and sepsis was confirmed histologically. No soft tissue malformations were noted grossly or histologically that were not related to the migration of the stingray spine from the eye to the aorta. Teeth were prepared and annular dentine layers read following standard procedures (Hohn et al., 1989), and the skeleton (Fig. 2) was prepared by wet maceration.

Condylobasal length (straight line measurement from the tip of the rostrum to the caudal edge of the occipital condyle) and TL were measured and compared with 140 bottlenose dolphins (75 females and 65 males) measured, with age determined by comparable methods. The average TL for the age class is 240–250 cm (SD = ±20 cm), far greater than MML0535’s 214 cm length. The trunk length (TL minus skull length) was compared with animals from similar size ranges. MML0535’s trunk length of 177 cm was well below the distribution of similar-aged animals and is comparable to the 4-yr-old age class (Read et al., 1993). The pattern of deformity included sequences of hemivertebrae (formation defects; Fig. 3); fused, undifferentiated lateral and transverse processes (segmentation defects; Fig. 4); an abnormally developed, curved, and malformed sternum; and undifferentiated ribs with some of the double-headed ribs (cranial most) presented as two ribs with a single body (Fig. 5).

Usual cervical presentation for bottlenose dolphins involves fusion of the atlas and axis, with the last five cervical vertebrae separate (Rommel, 1990). In contrast, MML0535 showed completely
fused cervical vertebrae (C1–7; Fig. 6) with the transverse processes of these vertebrae fused into a single block. Centra were compressed and appeared to be incompletely and asymmetrically separated. The appearance of the vertebrae was complicated by overgrowth of osteophyte and spondylosis deformans.

A fracture of the pedicle of the first thoracic vertebra (T1) existed immediately caudal to the fused section of cervical vertebrae (Fig. 6). The presentation of the fracture suggested a stress fracture due to the fusion of the cervical vertebrae, thus not allowing free movement. Many of the thoracic vertebrae were fused by their transverse processes (Fig. 4), with a section of normal vertebrae near the midpoint (T4–T5) and one section of vertebrae fused by the dorsal (spinous) process. Sections of vertebrae fused by transverse processes did not appear to have resulted in severe distortion, whereas the dorsally fused vertebrae appear to have resulted in kyphotic dorsal flexure.

The greatest distortion occurred around the hemivertebrae in the lumbar spine and had opposing hemivertebrae surrounding a single vertebra at L13–L15. These vertebrae were fused at the spinous processes, and the resulting segment was deformed both laterally and dorsally. There was severe degenerative osteoarthritis in the area of T8–L7, with deep subchondral cysts present and large areas of compensatory bridging. The largest sequence of normal vertebrae was present in the caudal section. It appeared that the caudal spine was the...
most flexible section of the spine even in the presence of a single-segmented hemivertebra.

The first two ribs were fully fused, separated only at their articulation with T1 and T2. There was also a unilateral set of similarly fused ribs at midthorax, reducing the overall number of free ribs. Given the asymmetry and deformation of the ribs and thoracic vertebrae, it was not surprising that the sternum was also grossly deformed. Because development of the sternum was influenced by the timing and growth of ribs, the abnormal separation and growth of the ribs likely resulted in the ribs joining the sternum unevenly with resulting distortion.

Cetaceans produce swimming thrust by dorsoventral oscillation of their caudal tailstock (Pabst, 2000). The muscular force works against the variably flexible vertebral column to create swimming movements (Arkowitz and Rommel, 1985). Any condition that impedes the flexibility or disrupts the linear alignment of the spine would, therefore, have potentially serious repercussions for movement and survival. Not only would misalignment impede movement, but a rigid spine is less able to bend or rotate on impact or when under...
stress either from movement or trauma (Resnick, 2002). The upper thoracic vertebral fractures of the skeleton of MML0535 seemed to underscore the severity of this problem.

Malformed vertebral elements can cause twisting of the spine from differential and asymmetrical growth. The severity and progression of the resulting spinal curvature are related to the type and location of the original malformation as well as to the developmental and compensatory changes as the animal grows. The effects may range from asymptomatic to severe distortion, with resultant secondary pathology ranging from compromised mobility to serious anatomical distortion. The progression of CS in dolphins is not known; however, it is safe to assume that deformity will be progressive and may increase during growth of the spine. In this case, the dolphin showed rib and sternal malformations as well as spinal deformities.

The true extent of skeletal pathology could not be evaluated until the full skeleton was completely cleaned and carefully examined. Because these developmental defects likely began at a time after the skull differentiated from the axial skeleton, the skull showed no signs of congenital deformity. It is, therefore, critical to examine postcranial skeletons for defects or conditions that may not be readily apparent through other methods.

**LITERATURE CITED**


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