

Diaphragmatic Hernia and Right-sided Heart Enlargement in a Florida Manatee (*Trichechus manatus latirostris*)

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ABSTRACT: Postmortem evaluation of a Florida manatee (*Trichechus manatus latirostris*) revealed cold stress lesions and previous watercraft trauma that included broken ribs, a diaphragmatic hernia, an enlarged vena cava, and right-sided cardiomegaly. We discuss these findings and present a possible pathogenesis for the cardiomegaly.

The Florida manatee (*Trichechus manatus latirostris*) is listed as an endangered species with watercraft collisions and loss of warm-water refugia identified as primary threats to the manatee population (Runge et al., 2007; International Union for Conservation of Nature, 2008). Although not a statistical estimate of manatee abundance in Florida, the highest number of manatees counted during a synoptic survey was 5,076 in January 2010 (Florida Fish and Wildlife Conservation Commission, 2012). We describe a diaphragmatic hernia resulting in cardiovascular disease in a manatee found dead with chronic watercraft-associated trauma and cold stress lesions.

In January of 2010, during record cold weather in Florida (mean ambient temperature of 14 C), an adult male manatee was found dead in the Peace River of Charlotte County (26°98'N 81°99'W). The 281-cm-long, 469.5-kg animal was brought to the Marine Mammal Pathobiology Laboratory in St. Petersburg, Florida, where a diagnostic necropsy was performed and samples for histopathologic interpretation were collected. The epidermis had generalized cutaneous lesions including epidermal hyperplasia, abscessation, and bleaching consistent with cold

stress syndrome (Bossart et al., 2002). There were six watercraft-related scars on the right dorsum, and a scar with an associated indentation on the right dorsal aspect of the animal head extending nearly the length of the skull.

The right 14th rib had distinct bony calluses at both the proximal and middiaphyseal levels. The 15th and 16th ribs on the ipsilateral side had chronic, nonunion fractures at the middiaphysis. The trauma to the ribs was deep to a large, well-healed scar on the right caudodorsal aspect of the body. The corresponding right hemidiaphragm had a 10-cm linear tear in the central tendon just medial to the right testis with smooth, healed margins. An organized hematoma (25×10×4 cm) was adhered to the pleural aspect of the right hemidiaphragm. A segment of retroperitoneal adipose tissue and approximately 280 cm of colon extended through the diaphragmatic defect into the thoracic cavity. The hernia was reducible with gentle retraction. The ventral aspect of the right lung was adhered to the hemidiaphragm. The cardiac right ventricle was severely enlarged and thin walled (Fig. 1). The heart weighed 2.23 kg and comprised 0.48% of the body weight. An internal review of all mortality records from 2008 to 2011 in which heart weights were ascertained and no gross cardiac pathology was noted ($n=70$) revealed an average cardiac to body weight percentage of 0.38%. The caudal vena cava was severely dilated (flat width of 5.0–7.0 cm throughout the length of the

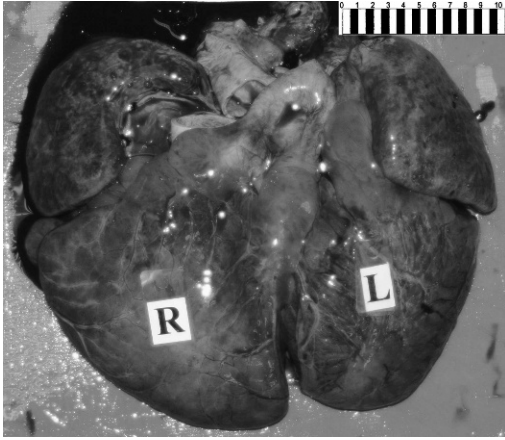


FIGURE 1. Photograph of a Florida manatee (*Trichechus manatus latirostris*) heart at the time of necropsy showing enlargement of the right ventricle and serous atrophy of epicardial fat. Note the size of the right ventricle (R) in relation to the left ventricle (L).

thoracic cavity). All adipose stores had moderate to marked serous atrophy.

Representative tissues were fixed in 10% neutral buffer formalin, routinely processed, sectioned at 5 μ m, and stained with hematoxylin and eosin for diagnostic light microscopy. Histologically, sections of right hemidiaphragm at the level of the defect were regionally distorted by mature fibrosis and chronic hemorrhage compatible with previous trauma. The right testis was atrophied and contained an old hematoma with hemosiderin deposition. In sections of liver, centrilobular to midzonal regions were moderately congested, and hepatocytes contained moderate cytoplasmic accumulations of hemosiderin identified using Prussian blue stain. Some central veins were surrounded by increased amounts of condensed fibrous stroma. Together, hepatic lesions were consistent with chronic passive congestion. No histologic abnormalities were detected in examined sections of heart. Remaining clinically significant histologic lesions were consistent with cold stress syndrome or starvation and included diffuse serous adipose atrophy and ulcerative/erosive dermatitis.

Although it is possible that the immediate cause of death was cold temperatures, no other cold-related mortalities were documented in this region during this time, and it was still considered early in the season for cold-related mortality, especially in a large adult animal. The case history, gross lesions, and histopathologic findings suggested multiple, chronic watercraft-related injuries were an important contributing factor to this animal's demise. The old blood clot within the right pleural cavity in addition to the close proximity of the hemidiaphragmatic tear to the hematoma in the right testis and the well-healed epidermal scars overlying this region suggested previous trauma to the caudal aspect of the animal's right side.

Herniated tissue, which composed approximately 30% of the right hemithorax, may have compressed portions of the right lung and pulmonary vasculature. Resultant pulmonary outflow tract obstruction could have led to right-sided cardiac insufficiency, as evidenced grossly by right ventricular dilatation and thinning and caudal vena cava distention, and histologically by hepatic chronic passive congestion. Right-sided cardiac insufficiency could have contributed to overall debilitation, and ultimately increased susceptibility to environmental factors such as cold stress.

Although traumatic diaphragmatic hernia (TDH) and right-sided heart failure have been well described in other species (Thebaud et al., 1998; Minihan et al., 2004; Bassareo et al., 2010; Keijzer and Puri, 2010), we know of no published reports of either disease process in the Florida manatee. Traumatic diaphragmatic hernia in small animals is most commonly associated with vehicular or blunt trauma (Schmiedt et al., 2003). In both humans and animals, TDH may go undiagnosed for months or years, and may even be an incidental finding (Minihan et al., 2004; Wright et al., 2005). Minihan et al. (2004) found that only 38% of patients with TDH were dyspneic, and

many presented for vague signs such as lethargy and anorexia. Diaphragmatic hernia as a cause of right-sided heart failure has been described in other species, including humans, dogs, and cats (Thebaud et al., 1998; Minihan et al., 2004; Bassareo et al., 2010; Keijzer and Puri, 2010). The pathophysiology of this disease process, as with other types of pulmonary outflow tract obstruction such as tumors, parasites, or granulomatous disease, includes an increase in blood volume to the right ventricle leading to eccentric hypertrophy of cardiac muscle fibers, enlargement of the right atrium and vena cava, and hepatic congestion (Bright et al., 1990; Kurzidim et al., 1998; Schwarzwald et al., 2006; Huang et al., 2009). There are no epidemiologic studies on the prevalence of cardiac disease in manatees, with the exception of one retrospective study that found endocardiosis to be relatively common (Buergelt et al., 1990).

In this animal, it is unclear whether the extreme cold weather or the right-sided heart disease ultimately led to its demise, and the cause of death was likely multifactorial. We conclude that diaphragmatic hernia and heart disease should be considered in any animal presenting to a rehabilitation center with evidence of trauma.

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