Pectus excavatum, which is from Latin meaning “hollow breast,” is a chest wall deformity seen frequently in humans and less often in veterinary patients. It has been described in dogs, cats, lambs, calves, rabbits and sea otters. It is a congenital defect where the caudal ribs and sternum do not grow properly resulting in a concavity starting around the 3rd to 5th rib and continuing to the xiphoid process. This deformity causes compression of the right side of the heart with deviation of the heart, to the left side of the thorax. Pectus excavatum is the most common chest wall deformity seen in both people and animals, accounting for 90% of human cases. In people, it occurs in approximately one in 400 live births and is more common in males with as high as a 9:1 ratio reported. It is not thought to be as common in animals and no sex predilection has been described. Pectus excavatum was first described in people the early 1600s and several case reports from the late 1800s were published. The first surgery for pectus excavatum was reported in 1911 and involved removal of rib cartilage. The first reported case of pectus excavatum in an animal was in 1968 in a Siamese cat. The first report in dogs was in 1973 in three Setter-cross littermates. Since that time, there have been numerous case reports of the condition, but because it is fairly rare, the literature is still limited.

The etiology of pectus excavatum is unknown. Early theories ranged from hypertension of the diaphragm, and nutritional disturbances causing a weakness of the sternum, to an increased intrauterine pressure, causing the fetus’ chin to compress the thorax. Current thought is that there is a defect in metabolism in the sternocostal cartilage that leads to biomechanical weakness and overgrowth. The condition has been shown to be genetic in people, with 43% of patients having a family history. There is an association with scoliosis and connective tissue disorders like...
Marfan, Noonan and Ehlers-Danlos syndromes. Predisposition for pectus excavatum is seen in Bengal and Burmese cats as well as brachycephalic dogs, most commonly in the Maltese and English Bulldog. Acquired pectus excavatum has been reported in people secondary to respiratory obstruction and there is a single case report describing acquired pectus excavatum in a dog secondary to laryngeal paralysis. Recently, a rat model for pectus excavatum has been reported where removal of the last four costal cartilages results in collapse of the sternum.

Pectus excavatum is present at birth and is detectable within days in puppies and kittens. The defect worsens with growth and in people it is sometimes not obvious until adolescence. Once growth ceases, the condition does not progress. The clinical signs can be variable with most cases in humans presenting with mild signs or concern about cosmesis. In severe cases, disabling cardio and respiratory compression is present and clinical signs worsen with age. Dyspnea, chest pain, fatigue, palpitations, tachycardia, and exercise intolerance have all been reported in people. Dyspnea is the most common clinical sign in animals. Exercise intolerance, inappetence, recurrent respiratory infections, weight loss, cough, cyanosis, and heart murmurs are also reported.

Pectus excavatum is diagnosed on physical examination however imaging helps to determine the severity of the condition. The anthropometric or clinical index, measures the depth of the defect and compares it to the depth of the thorax. This is a simple test that requires no additional equipment. Radiographs show the degree of deformity and can be used to calculate several different indices which assess the amount of compression. The frontosagittal index (FSI) compares the width of the thorax at its widest point with the depth of the thorax at its most narrow point and a ratio is determined. The vertebral index (VI) compares the distance between the dorsal border of the spine and the sternum at the narrowest point, with the depth of a vertebral body. In animals, two view thoracic radiographs can be used to calculate both the FSI and the VI and when combined with clinical signs, help to determine if surgery is recommended. The Haller index (HI), also called the pectus index, was first described in 1987 and is calculated by dividing the transverse diameter of the chest by the narrowest anterior-posterior distance on a computed tomography (CT) scan axial slice. The Haller index is the most commonly used pectus excavatum index used in people. It can also be calculated using plain film and has been shown to correlate well with the CT calculations. Indices may not correlate with clinical signs in some cases. CT scan has been shown to result in a lower vertebral index and a higher frontosagittal index in kittens when compared to radiographic measurements. CT was useful in determining if the xiphoid was midline or lateralized with the thought that midline defects cause more clinical signs. CT scan also helped determine safe corridors for surgical suture placement.

Treatment for pectus excavatum depends on the severity of the clinical signs. Pain is a common complaint in human patients and non-steroidal anti-inflammatory medication and acupuncture have been reported to help. Physical therapy has been recommended to help strengthen the chest muscles and help develop the ribcage. Daily medial lateral compression of the chest or compression bandages have been described for neonatal puppies and kittens however, this is unlikely to improve severe deformities. In people, the use of a vacuum bell has been reported with success in milder cases and in young patients who still have a compliant thorax. Several hours of daily use is required and patients wear the device for up to two years after the deformity is corrected. In the case of severe pectus excavatum or in older patients, surgery is required. The two most commonly performed surgeries are the Ravitch procedure and the less invasive Nuss procedure. The Ravitch procedure involves an open surgical approach with removal of the deformed cartilage and metal bars are implanted to support the sternum. This is a long
procedure with potentially significant morbidity. The Nuss procedure is performed under thoracoscopic guidance and a curved metal bar is placed and then flipped into position to raise the sternum.\textsuperscript{21,22,23} In veterinary patients, the choice of surgery is dependent on age. In older animals, an open approach is required to correct the deformity. Ostectomy of a portion of the costal cartilage is required to allow the sternum to be realigned and an internal splint, such as a bone plate, is used to keep the sternum in this position.\textsuperscript{24} An open approach to release the sternum, combined with an external splint has also been described.\textsuperscript{25,26} Animals less than 4 months of age will typically have a compliant thorax and external splints with circumsternal sutures can be used.\textsuperscript{27} The sutures are tied to the splint to keep the thorax in a normal position and the splint is left in place for 3 to 4 weeks.\textsuperscript{27,28,29} Complications associated with surgery include inadvertent puncture of the lungs or heart, pneumothorax, hemorrhage and re-expansion pulmonary edema which can be fatal.\textsuperscript{28,30} Minor complications include bandage sores and abrasions from the splint or reaction to the sutures. Anesthesia in patients with pectus excavatum can be challenging.\textsuperscript{31} Ninety-five percent of patients present with some degree of ventricular compression.\textsuperscript{31} Heart murmurs and arrhythmias are common.\textsuperscript{14,31} Underlying respiratory disease including infections should be treated prior to surgery and assisted ventilation is needed during anesthesia. Because surgery is often performed in very young puppies and kittens, their body temperature should be carefully monitored as their thermoregulation is not fully developed and they have little fat. Their metabolism rate is higher than adult patients and as a result, they require shorter fasting times and higher fluid rates.\textsuperscript{14} Enzymes systems should be fully developed by 4 weeks allowing the use of injectable medications.\textsuperscript{14}

Pectus excavatum is a treatable condition that has a favorable prognosis in puppies and kittens. Severe cases can do well with surgery. A procedure with circumsternal sutures and an external splint is the most commonly performed in young animals. Surgery is best accomplished between 8 and 12 weeks when the thorax is still compliant but the patient is old enough to tolerate anesthesia.

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