Remnant parietal serosa detection in a cat with true diaphragmatic hernia using computed tomography

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Abstract: A 4-year-old cat was referred for a suspected pulmonary mass. True diaphragmatic hernia presence was diagnosed *via* computed tomography (CT). There was a thin membrane covering the diaphragmatic defect. The membrane was thinner than the diaphragm. After contrast injection, the membrane was less enhanced than that of the normal diaphragm. The membrane was identified as a remnant of the parietal pleura. In addition, contrast-enhanced CT images provided clarity in viewing the herniated liver and falciform fat. A thinner membrane, covering the diaphragmatic defect, and attached to the thicker normal diaphragm, is considered a unique CT feature of true diaphragmatic hernia.

Keywords: cat, computed tomography, intact membrane, parietal serosa, true diaphragmatic hernia

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Introduction

True diaphragmatic hernia, a rare congenital diaphragmatic defect, is an incomplete tear of the diaphragm in which communication between peritoneal and pleural cavities is prevented by the remnant intact serosa on the thoracic surface. Thus, true diaphragmatic hernia is characterized as a hernia sac surrounded by serosa, and these unique features are different from those of other types of diaphragmatic hernia. Most previous cases with true diaphragmatic hernia were confused with pulmonary mass or peritoneopericardial diaphragmatic hernia on radiography and confirmed as true diaphragmatic hernia through surgery or necropsy [1-5]. In four cases, positive contrast peritoneography diagnosed true diaphragmatic hernia by revealing incomplete diaphragmatic defects between peritoneal and pleural cavities [6-8]. Recently, a single case report described computed tomography (CT) features of true diaphragmatic hernia in a cat [8]. However, there are no previous reports focusing on the imaging characteristics of the remnant intact serosa. This case report describes a thin membrane connected with the diaphragm and creating a hernia sac on CT images in a cat with true diaphragmatic hernia. This membrane was indicated as a remnant serosa, and this CT features may be a specific sign of true diaphragmatic hernia.

A 4-year-old male neutered Persian cat was referred to Chonnam National University Veterinary Teaching Hospital. The cat was referred for evaluation of a suspected pulmonary mass, identified on thoracic radiography during a health inspection. On presentation, the cat was asymptomatic, and its complete blood count and serum biochemistry results were unremarkable.

On thoracic radiographs, a round, soft tissue mass was observed between the caudal border of the heart and the diaphragm (Fig. 1). In contrast to the distinct cranial margin, the mass had an indistinct caudal margin, and a silhouette sign was present with the diaphragm. Differential diagnoses for the lesion included a mass originating from the accessory lung lobe, diaphragm, or caudal mediastinum; diaphragmatic rupture; and true diaphragmatic hernia.

The intrathoracic mass was identified on ultrasonography. A hyperechoic diaphragm was not observed between the mass and the liver, and the mass appeared to be connected to the liver. The mass was more hypoechoic than the liver, and vascular structures were not clearly observed. Based on the ultrasonographic observations, diaphragmatic hernia of the liver was suspected.

Fig. 1. Thoracic radiographs of a cat; right lateral (A) and ventrodorsal (B) views. A round soft tissue mass (asterisk) is located between heart and diaphragm. The caudal margin of the mass effaced the cranial border of the diaphragm.

The CT was performed by using a 16-row multi-detector CT scanner (Siemens Emotion 16, Siemens, Germany). General anesthesia was induced by ketamine hydrochloride (Ketamine, Yuhan, Seoul, Korea; 5 mg/kg, IM), and maintained with isoflurane (Terrell, Piramal Critical Care, USA; 1-2%) and oxygen (1 L/min). The cat was positioned in sternal recumbency and pre- and post-contrast CT images of the thorax and abdomen were acquired at the following settings: slice thickness, 1 mm; pitch, 0.7; rotation duration, 500 msec; tube voltage, 120 kV, and tube current; 120 mA. To reduce motion artifact, the cat was hyperventilated before CT scanning. Post-contrast CT study was performed after a bolus injection of 600 mg I/kg iohexol (Omnipaque 300, GE Healthcare, Oslo, Norway). Soft and sharp algorithms were used to generate images, and the transverse, dorsal, and sagittal planes were reconstructed. On CT images, the diaphragm had a defect at the center (Fig. 2). The thoracic mass pro-

truded through the defect in the diaphragm, from the abdomen caudal into the thorax. The mass consisted of liver and falciform fat, and was confined within a thin membrane that created a pouch-like hernia sac. The membrane (less than 1 mm) was thinner than the adjacent diaphragm (4.1 mm); however, it was connected to the diaphragm and prevented communication between the hernia sac and the pleural cavity. Mediastinal fat, adjacent to the hernia sac, enabled visualization of the pleural side of the membrane. After contrast injection, the hepatic vein and hepatic portal veins were observed in the herniated liver. Vascular obstruction or thrombi were not observed. Based on the distribution of the intrahepatic vessels, the herniated liver portion was determined to be the left medial or quadrate liver lobe. Contrast enhancement of the herniated liver lobe (177 Hounsfield units [HU]) was higher than that of the abdominal liver lobes (149 HU). A small volume of fluid was observed within the hernia sac,

Fig. 2. Transverse (A) and dorsally reformatted (B) soft tissue window images before contrast injection. The diaphragmatic defect is observed between the intrathoracic mass (asterisk) and the peritoneal cavity (B). The herniated mass is composed of soft tissue structures and falciform fat, and a thin membrane (arrows) surrounds the herniated mass. This membrane is connected with the outer layer of the normal diaphragm (dashed arrows), and is thinner than the diaphragm (B).

Fig. 3. Transverse (A) and sagittal (B) images after contrast injection. Hepatic vasculature is evident in the herniated soft tissue structure. Observation of hepatic vessels confirms the liver herniation; in this case, the left medial or quadrate lobe. Attenuation of the herniated liver lobe (asterisk) is higher than that of the remaining lobes (l), and a small volume of fluid (arrow) is observed adjacent to the herniated liver.

and mild congestion of the herniated liver was suspected. The thin membrane enhanced to a lesser degree than that of the normal diaphragm, although the membrane was too thin to be numerically measured via CT (Fig. 3). There were no other abnormal findings in the thorax and abdomen. The cat was diagnosed with true diaphragmatic hernia, along with a mildly congested liver and falciform fat. The cat was asymptomatic, and there was no pulmonary collapse identified on CT images; therefore, monitoring of the herniated liver lobes was recommended, without additional treatment.

Because true diaphragmatic hernia is a rare diaphragmatic hernia and most of them may be mistaken for a mass originating from the lung, diaphragm, or caudal mediastinum; diaphragmatic rupture and peritoneopericardial diaphragmatic hernia on radiography and ultrasonography, reports on the diagnostic features of true diaphragmatic hernia are limited. Positive contrast peritoneography in four cases confirmed true diaphragmatic hernia diagnoses by revealing round pouch-like structures protruding into the thoracic cavity and no communication between the structures and the pleural cavities [3,6,7]. However, this contrast technique is limited in its ability to characterize the herniated organ and the diaphragmatic layer.

In humans, CT is preferred for evaluation of diaphragmatic hernia because the technique can confirm the presence of a hernia and assess the herniated organs and the involved diaphragm [9,10]. A diaphragmatic eventration, one of the diaphragmatic diseases, is commonly reported in humans [2]. A congenital eventration is characterized by muscular aplasia of the diaphragm. In acquired eventration, diaphragmatic paralysis and cranial displacement of the entire diaphragm due to trauma or surgical injury are observed. A diaphragmatic eventration is referred to as true diaphragmatic hernia in veterinary medicine and is defined as a subtotal diaphragmatic tear in which the serosa on the thoracic surface of the diaphragm remains intact [4,6]. On CT images of diaphragmatic eventration, focal bulging of the affected diaphragm forms a hernia sac containing herniated abdominal structures [10]. In

particular, a thin layer of the diaphragm can be identified between the hernia and the pleural cavity, and the layer forms a sharp transitional edge between the normal diaphragm and itself. This characteristic CT finding is dissimilar from those for congenital diaphragmatic hernia or diaphragmatic rupture.

On CT images of the present case, a hernia sac, consisting of a thin membrane, was observed instead of a complete diaphragmatic defect, and the membrane enclosed the herniated liver lobe and falciform fat. The thin membrane prevented communication between the peritoneal and pleural cavities and was connected to the normal diaphragm. These CT observations correspond with previous surgical examinations revealing that the encapsulating layer surrounding the herniated organ was confluent with the diaphragm, and that the membrane was considered as a remnant of the parietal serosa of the diaphragm [1,4,5].

The remaining diaphragmatic membrane is not considered pathognomonic of true diaphragmatic hernia, since it may be only identified when it borders fat. In this case, the pleural side of the membrane adjoined the mediastinal fat, and the peritoneal side adjoined the falciform fat. In a previous case diagnosed via CT [8], the remaining diaphragmatic layer was silhouetted against the herniated liver and not identified separately from it.

Most cases of true diaphragmatic hernia were associated with a lack of clinical signs except for two neonatal cats with severe dyspnea due to compression of the lung lobes by cranial displacement of abdominal organs [1-8]. Exploratory laparotomy was performed in most previous cases in order to diagnose true diaphragmatic hernia and correct it. The present cat had CT-confirmed true diaphragmatic hernia but was asymptomatic; thus, clinical monitoring was recommended without surgical correction.

In conclusion, CT evaluation was useful for determination of the type of diaphragmatic hernia and for assessment of the herniated abdominal structures. A thin membrane, covering the diaphragmatic defect and connecting with the diaphragm

indicated a remnant of the parietal serosa; such a membrane can be used as a specific CT feature of true diaphragmatic hernia.

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