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Source: Journal of Feline Medicine and Surgery Open Reports, 5(1)

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/2055116919835081>

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Journal of Feline Medicine and Surgery Open Reports
1–5

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DOI: 10.1177/2055116919835081

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This paper was handled and processed by the European Editorial Office (ISFM) for publication in *JFMS Open Reports*



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Abstract

Case summary A 14-year-old female neutered Persian-cross cat was presented with a 1 week history of anorexia and lethargy. On physical examination, marked tachypnoea and dyspnoea were evident. Radiographs of the thorax revealed a globoid-shaped cardiac silhouette with heterogeneous opacity consistent with a peritoneopericardial diaphragmatic hernia (PPDH), pulmonary nodules compatible with metastasis, seven sternal segments and a small liver in the cranial abdomen with loss of serosal detail. On echocardiography, there was no evidence of cardiac tamponade. Triple-phase CT angiography demonstrated a mixed soft tissue-, mineral- and fat-attenuated liver mass arising from the left hepatic lobes that showed a pronounced heterogeneous contrast-enhancement pattern within the pericardial sac, which was producing a marked mass effect on the adjacent structures. Additionally, there was an increase in attenuation of the mesenteric fat and peritoneal effusion. The pulmonary nodules were confirmed. Imaging findings were compatible with a malignant hepatic neoplasia incarcerated in a PPDH, lung metastasis and carcinomatosis. Owing to the poor prognosis, the cat was humanely euthanased. Histopathological diagnosis was cholangiocellular carcinoma and hepatic myelolipoma, pulmonary metastasis and carcinomatosis.

Relevance and novel information Hepatic cholangiocarcinoma incarcerated in a PPDH with pulmonary metastasis and carcinomatosis has not been previously described. Suspicion of a hepatic neoplasia should be raised in cases of PPDH and pulmonary nodules.

Keywords: Peritoneopericardial diaphragmatic hernia; cholangiocarcinoma; myelolipoma; CT

Accepted: 1 February 2019

Introduction

Cholangiocellular carcinoma refers to a malignant liver tumour originating from the intrahepatic and extrahepatic bile duct epithelium.¹ It is an unusual liver neoplasia in cats. There is no apparent breed or sex predisposition, although it is commonly found in animals older than 10 years of age.¹

Previous case reports have documented a possible association between the herniated liver in a peritoneopericardial diaphragmatic hernia (PPDH) and the development of different hepatic conditions such as myelolipomas, cysts and fibrosarcomas.^{2–4}

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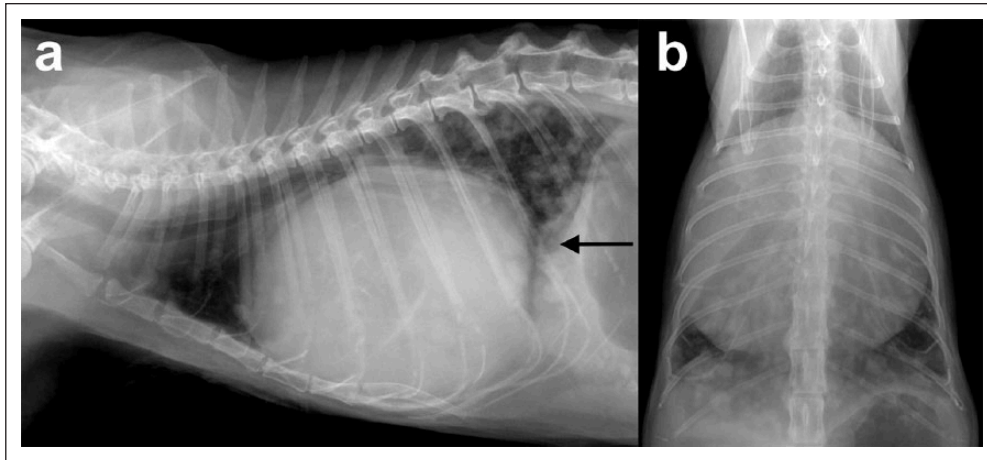


Figure 1 (a) Right lateral and (b) dorsoventral radiographs of the thoracic cavity. Note the globoid-shape cardiac silhouette with a heterogeneous appearance encompassing the total width of the thoracic cavity, dorsal peritoneopericardial mesothelial remnant (arrow), ventral diaphragmatic border effacement, multiple soft tissue opacity pulmonary nodules and a small liver in the cranial abdomen. Only seven sternal segments are identified

Herein we describe the diagnostic imaging findings using radiography, ultrasound and triple-phase CT angiography (CTA) of a cat with a cholangiocellular carcinoma and hepatic myelolipoma incarcerated in a PPDH with pulmonary metastases and carcinomatosis.

Case description

A 14-year-old female neutered Persian-cross cat was referred for evaluation of suspected pericardial effusion. It was presented to the referring veterinarian with a 1 week history of anorexia and lethargy. On physical examination, the cat was alert and responsive, and its body condition score was 4/9, with slightly pale mucous membranes and weak peripheral pulses. It was markedly tachypnoeic and dyspnoeic. Heart rate was 200 beats per min. Auscultation revealed decreased bronchovesicular sounds on both sides of the thorax.

Blood analyses revealed a mild non-regenerative anaemia and mildly elevated alanine aminotransferase and aspartate aminotransferase.

Radiographs of the thorax and abdomen were taken using a computed radiography unit (CR 30-X; Agfa Healthcare). Technical parameters were 55 kVp and 4 mAs. The radiographs showed ventral diaphragmatic border effacement with a severely enlarged, globoid-shaped cardiac silhouette with a heterogeneous opacity, and a dorsal peritoneopericardial mesothelial remnant. These findings were consistent with a PPDH. Additionally, an interstitial-nodular lung pattern was seen, most likely compatible with metastasis. Seven sternbral segments were identified (Figure 1). In the abdomen, a moderate loss of serosal detail, microhepatia and cranial displacement of the spleen were observed.

Thoracic ultrasound revealed a heterogeneous mass with hyperechoic foci, a hyperechoic strong-attenuating



Figure 2 Ultrasonographic image of the mass from the right thoracic wall. The mass is of mixed echogenicity and surrounded by anechoic free fluid (asterisk)

region and hypoechogenic areas within the pericardial sac. The mass was surrounded by anechoic fluid (Figure 2), but there was no evidence of cardiac tamponade. To better characterise the mass within the pericardial sac a whole-body triple-phase CTA was performed using a dual-slice CT scanner (General Electric HiSpeed; General Electric Healthcare) under general anaesthesia. The patient was positioned in sternal recumbency. Pre- and post-contrast images following administration of iopromide (Omnipaque, 300 mg/ml; Schering) at 600 mg I/kg and at 3 ml/s into a cephalic vein catheter by angiographic injector (A-60; Nemoto) were acquired at 12, 30 and 90 s for the arterial, portal and delayed phases, respectively. Technical parameters were 120 kV tube voltage, 120 mAs

tube current, 1 s tube rotation time, helical scan mode, collimator pitch of 1 and 3 mm slice thickness and reconstructions interval with 50% overlap. The display field of view was 43×43 cm and image matrix was 512×512 . Reformatted images in sagittal and dorsal planes were obtained. The images were reviewed in a Picture Archiving and Communication System (PACS) workstation in lung (window width [WW] = 1500; window level [WL] = -500), soft tissue window (WW = 350, WL = 40) and bone (WW = 1500, WL = 300) windows.

The CT scan demonstrated a mixed soft tissue- and fat-attenuating hepatic mass within the pericardial sac that emerged from the left liver lobes (probably involving the quadrate, left medial and left lateral lobes) as these were not identified within the abdominal cavity. This mass showed a marked heterogeneous contrast-enhancement pattern in the arterial and portal phases that became more homogeneous in the delayed phase. In addition, multiple hypoattenuating non-enhancing round-shaped areas were identified, consistent with cystic or necrotic areas, as well as a few mineralised foci within the soft tissue mass. A thin mineral and irregular band was enclosing the fat-attenuated area. The gall bladder was not identified. The mass was mildly displacing the cardiac silhouette cranially and towards the left. The heart and the mass were surrounded by non-contrast-enhancing fluid (20 Hounsfield units). A diffusely thickened and enhancing pericardium was seen. The whole pericardial sac was producing a marked mass effect dorsally on the caudal mediastinal structures, flattening the post-hepatic segment of the caudal vena cava and filling the total

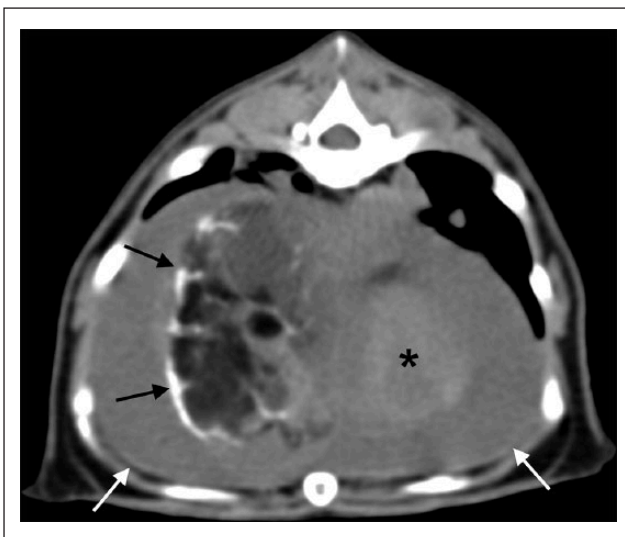


Figure 3 Pre-contrast transverse CT image of the pericardial sac in soft tissue window (window width = 350, window level = 40). The cardiac silhouette (asterisk) is medial to the fat-attenuated mass, which is surrounded by a thin and irregular mineral band (black arrows). The heart and the mass are surrounded by fluid (white arrows)

width of the thoracic cavity (Figures 3 and 4). In the pulmonary parenchyma, multiple soft tissue-attenuating nodules of different sizes were identified. There was an increase in density of the mesenteric fat and abdominal effusion. There was no evidence of thoracic or abdominal lymphadenopathy.

CT findings were consistent with a malignant hepatic neoplasia incarcerated in a PPDH, lung metastasis and carcinomatosis. The owner elected humane euthanasia owing to the severity of the clinical signs and guarded prognosis.

On post-mortem examination, a tan-coloured soft tissue mass consistent with a hepatic lobe was identified within the pericardial sac. Nodular masses were observed in all lobes of the lungs, compatible with metastasis (Figure 5). Under microscopic examination of the liver with haematoxylin and eosin staining, neoplastic cells



Figure 4 Post-contrast dorsal CT reconstruction in the delayed phase of the thoracic cavity in soft tissue window (window width = 350, window level = 40). There is a large and heterogeneous mass (black arrows) with a focal area of fat density (white dashed arrows) arising from the liver in the pericardial sac displacing the cardiac silhouette (asterisk) cranially, which is surrounded by non-enhancing fluid. Note the absence of liver parenchyma in the left cranial abdomen

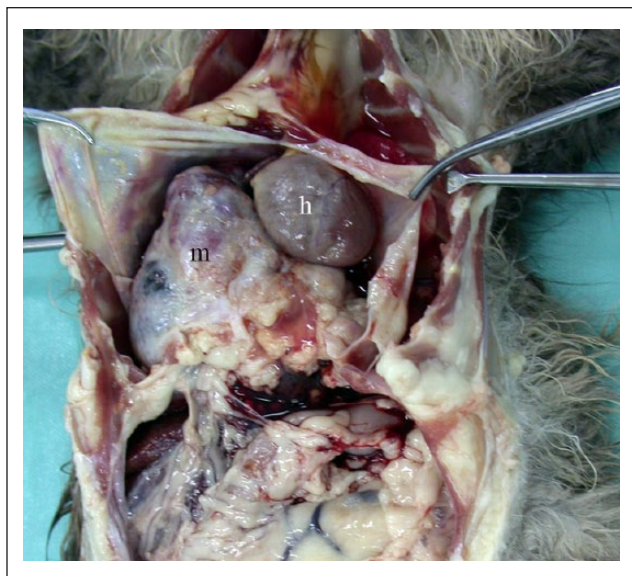


Figure 5 Gross image from the thorax necropsy. Note the hepatic mass (m) displacing the heart (h) towards the left side within the pericardial sac

appeared in an irregular tubular arrangement. The epithelium lining of the tubular structures was cuboidal to columnar. Pleomorphism was moderate. It was observed as an abundant deposition of collagen among groups of neoplastic cells and in the interface with the normal hepatic parenchyma. Small areas of necrosis were present within the groups of neoplastic tubular structures. Local invasion of surrounding hepatic parenchyma was observed in the margins of the neoplasia (Figure 6).

In the lung, the nodules were formed by cells organised into tubules of irregular morphology located between the pulmonary alveoli with presence of abundant connective tissue, like the structures observed in the liver.

The histopathological diagnosis of the hepatic mass, lung and mesenteric fat was hepatic cholangiocellular carcinoma and myelolipoma, pulmonary metastasis and carcinomatosis.

Discussion

Peritoneopericardial diaphragmatic hernia is an uncommon congenital defect characterised by a communication between the pericardial sac and peritoneal cavity.⁵ In most instances, it is considered an incidental finding. Clinical signs, when present, might be directly related to the size of the hernia and to the organ or organs herniated in the pericardial sac. Clinical signs are often attributable to the respiratory or gastrointestinal system, with exercise intolerance, tachypnoea, dyspnoea and cough the most common at presentation.^{5,6} In our case, the major clinical signs were anorexia, lethargy and tachypnoea, and decreased bronchovesicular sounds. All these clinical signs were due presumably to the cholangiocellular carcinoma herniated in the pericardial sac of PPDH and metastasis.

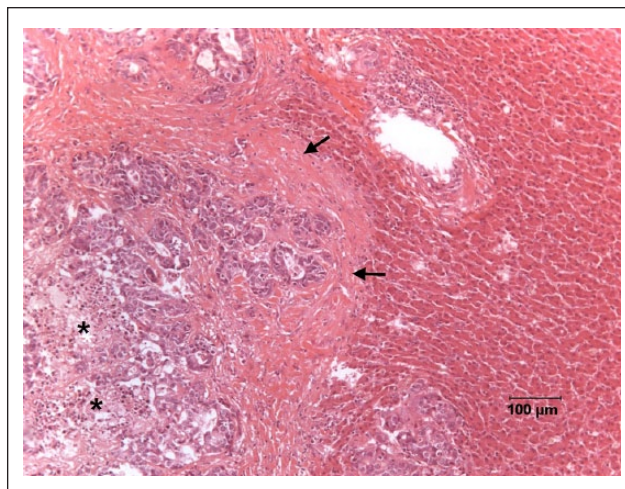


Figure 6 Primary focus of a cholangiocarcinoma in the liver. Note the presence, on the left side of the image, of areas of necrosis (asterisks). In the centre the neoplastic cells appear organised in small irregular tubules accompanied by a desmoplastic reaction (arrows)

The typical radiographic features of PPDH were present as previously described.⁶ In addition, a heterogeneous opacity of the cardiac silhouette was observed, which was due to superimposition of irregular mineral bands surrounding the areas of fat opacity. These findings were confirmed by the CT examination. It remains unknown if this mineralisation occurs because of pressure or ischaemia due to fat entrapment within the pericardial sac. A similar mechanism happens with nodular fat necrosis or Bate's bodies, which is a differential diagnosis of mineral opacities within the pericardial sacs of cats with PPDH.⁷ Other congenital pathologies related to PPDH might be evidenced such as pectus excavatum and different sternal abnormalities, among others. In this cat, only seven sternal segments were identified, and a shortened sternum can result in an incomplete attachment of the diaphragm to the xiphoid process.⁸

Although primary hepatic neoplasia is infrequently described in cats, cholangiocellular carcinoma has been reported to encompass approximately 24% of primary liver tumours in cats, being considered the most common non-lymphoid hepatic tumour. This hepatobiliary neoplasm demonstrates an increased presentation in female cats without breed predisposition. They are often found in elderly cats (aged >10 years) and the clinical signs can be absent or very non-specific. The most frequent sites of metastases are the peritoneum (in up to 80% of cases), lung, regional lymph nodes and spleen, among others. It rarely produces spontaneous rupture and haemoabdomen,⁹ and it has been associated with the trematode *Clonorchis sinensis* in humans, as well as with chronic exposure to different toxic agents.¹ The case described here was a 14-year-old

female Persian-crossed cat, without previous history of toxic exposure. Metastases were observed within the lung and peritoneum, which produced an exudative effusion in the abdomen secondary to the carcinomatosis.

An association between PPDH and incarcerated hepatic cholangiocarcinoma has not been previously described in cats, to our knowledge. Other hepatic conditions, such as cysts, myelolipomas and a fibrosarcoma, have been described associated with the herniated liver lobes and are thought to be secondary to vascular and lymphatic congestion of the incarcerated tissue with secondary chronic hypoxia, leading to an increased risk of neoplastic transformation.⁴ In humans, ectopic livers are predisposed to hepatocarcinogenesis due to longer exposure to carcinogenic substances as a result of incomplete vascular and ductal systems.⁴ These pathogenesis mechanisms could also have led to a neoplastic transformation of the bile duct epithelium, generating the development of cholangiocarcinoma within the incarcerated liver tissue.

The CT findings of cholangiocarcinomas in cats have not been previously described. In humans, they are described as irregular and lobulated masses with stippled hyperattenuating foci, and dynamic studies demonstrate rim-like enhancement in the early phases, with progressive concentric filling. In this case, a few mineralised foci were identified within the mass. There was no evidence of a peripheral-enhancing pattern in the early phases; the contrast-enhancement pattern was heterogeneous in the arterial and portal phases and became more homogeneous in the delayed series. This could be due to the fact that the mass was associated with cystic-like lesions and an adjacent myelolipoma. The diminished blood supply to the mass secondary to the PPDH could also have played a major role in the contrast-enhancing pattern.

However, myelolipomas are considered a benign hepatobiliary tumour in cats, composed of adipose tissue and haematopoietic cells.¹⁰ These benign tumours have previously been associated with PPDH,^{2,3} and are thought to occur secondary to chronic hypoxia. Some authors have speculated a possible development of myelolipomas associated with adjacent foci of tumour necrosis from a different neoplasm, as they have occurred synchronously with hepatocellular carcinomas.¹⁰ Therefore, in addition to the possible chronic hypoxia due to the PPDH, the myelolipoma of the current case could also have occurred in association with the adjacent cholangiocarcinoma. Other adipose tissue neoplasms in veterinary medicine include lipomas, angiolipomas, infiltrative lipomas and liposarcomas. Liposarcomas have not been described in the liver and they should be included as a differential diagnosis for mixed soft tissue-and fat-attenuating masses, although these neoplasms tend to have a more heterogeneous

appearance, greater density and enhancement following contrast administration than in our case.¹¹

Conclusions

This is the first description of the radiographic, ultrasonographic and triple-phase CTA findings of an elderly cat with a PPDH and neoplastic transformation of the incarcerated liver into a cholangiocellular carcinoma and myelolipoma with pulmonary metastasis. Therefore, suspicion of a hepatic neoplasia should be raised in cases of PPDH and pulmonary nodules.

Conflict of interest The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding The authors received no financial support for the research, authorship, and/or publication of this article.

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