1. Title page

Title:

Imaging Diagnosis: The Computed Tomography Features Of A Pleuroperitoneal Hernia In A Cat

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CT Pleuroperitoneal Hernia In A Cat

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2. Abstract

An 8-year-old female neutered domestic short hair cat presented for investigation of poorly controlled diabetes mellitus. Thoracic radiographs identified a soft tissue opacity in the caudoventral thorax adjacent to the diaphragm. Computed tomography (CT) then characterised a pleuroperitoneal hernia with cranial displacement of a portion of the liver within the hernia. A pleuroperitoneal hernia was confirmed and repaired via exploratory laparotomy. This is the first description of the CT features of a pleuroperitoneal hernia in a cat.

3. Text:

Signalment, history, and clinical findings

An 8-year-old female neutered domestic shorthair cat presented to the primary care veterinarian with a 2-week history of weight loss, polydipsia and polyuria and was diagnosed with diabetes mellitus. Although the cat became less polydipsic and polyuric with treatment, weight loss continued and inappetence developed. Thus, the cat was referred to the authors' institution 6 weeks after the initial presentation.

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Imaging diagnosis and outcome

Thoracic radiographs (68 kVp 3.2mAs Imaging Plate Type CC, Reader FCR Capsula XL, Fujifilm Medical Systems Inc, Stamford, CT) including right lateral recumbency, left lateral recumbency and ventrodorsal projections were acquired following oesophageal feeding tube placement. A well circumscribed soft tissue opacity in the caudal thorax that was dome shaped with the broad base contiguous with the diaphragm was present. The convex surface of the soft tissue opacity extended cranially towards the cardiac silhouette without direct contact with the caudal border of the cardiac silhouette. The dorsal margin of the soft tissue opacity was superimposed over the caudal vena cava and the ventral border extended to the costochondral junctions. The soft tissue opacity was midline and was not visualised on the ventrodorsal projection. The remainder of the thoracic structures were within normal limits and the endotracheal and oesophageal feeding tubes were visualised (Figure 1).

Differential diagnoses for the soft tissue opacity included a caudal mediastinal or accessory lung lobe mass (such as granuloma, neoplasia, abscess, cyst, haematoma), diaphragmatic hernia including pleuroperitoneal hernia, chronic diaphragmatic rupture with cranial displacement of abdominal contents, and diaphragmatic eventration. Peritoneopericardial diaphragmatic hernia could also be considered as the absence of the dorsal peritoneopericardial mesothelial remnant does not exclude this differential diagnosis.¹ Abdominal ultrasound (Acuson X300™, Siemens Medical Solutions, Malvern, PA with curvilinear C8-5 MHz and linear VF13-5 MHz transducers), identified cranial displacement of a portion of the liver into the caudal thorax, which narrowed the differential diagnoses to congenital diaphragmatic hernia, including pleuroperitoneal hernia, diaphragmatic eventration, peritoneopericardial hernia or chronic diaphragmatic rupture. These findings were considered to be incidental and unlikely to be contributing the current clinical problem of poorly controlled diabetes mellitus. Thoracic radiographs were repeated four days later and the previously described radiographic findings were unchanged.

Despite ongoing nutritional support via an oesophageal feeding tube, tailored insulin therapy and supportive treatment, the cat did not clinically improve in terms of appetite or diabetic control. A definite cause for the inappetence could not be identified despite extensive work up, which included haematology, serum biochemistry, feline pancreatic lipase immunoreactivity analysis, urine analysis, urine culture, abdominal ultrasonography and aspirates of the liver and prominent mesenteric lymph nodes. Thus, surgical exploration and biopsies of liver, pancreas and intestine (full-thickness) were recommended. Computed tomography examination of the thoracoabdominal junction was performed 11 days after the initial radiograph for pre-surgical evaluation and to assess the affected diaphragm. The cat was anaesthetised, placed in sternal recumbency and the CT images (SOMATOM® Emotion 16, Siemens Medical Solutions, Forchheim, Bavaria) were acquired in the transverse plane, from the level of the fourth thoracic vertebra caudally to the level of the third lumbar vertebra, pre and post contrast the image acquisition parameters were 110 kV and 26 mA with a slice thickness of 2 mm. The pre contrast images were reconstructed using smoothing and edge enhancement algorithms, viewed in both soft tissue and lung windows and reformatted into 1mm slices in transverse, dorsal and sagittal image planes. Intravenous contrast (720 mgI/kg Omnipaque™ 240 mg/ml, General Electric Healthcare, Mississauga, ON) was administered, via the left saphenous vein using a power injector (Salient™ CT contrast injection system, Imaxeon, Rydalmere, NSW) at the rate of 3 ml/s, and images were acquired in both arterial and venous

phases. The post contrast images were reconstructed using smoothing algorithms, viewed in soft tissue windows and reformatted into 1mm slices in transverse, sagittal and dorsal image planes. The CT images were transferred to the picture archiving and communication system (Synapse® Version 3.2.1, Fuji Medical Systems Inc, Stamford, CT) and viewed on a dedicated workstation (Multisync LCD 2190UXp, NEC, Chicago, IL).

The CT examination confirmed the herniation of the liver in the ventral midline, to the left of the caudal vena cava. The base of the herniated liver was adjacent to the level of the diaphragm and extended dorsoventrally for 17 mm. The triangular shaped herniated liver projected cranially for 20 mm towards the cardiac silhouette. The post contrast arterial and venous phases identified branches of the left hepatic and left portal veins extending into the herniated liver which confirmed that the contents of the hernia were contiguous with the abdominal liver and likely from the left medial liver lobe (Figure 2). There was extension of the pericardial fat caudodorsally from the pericardium to the craniodorsal margin of the herniated liver, although no direct communication with the pericardial sac was identified (Figure 3).

The cat underwent a midline exploratory laparotomy and a pleuroperitoneal hernia, containing liver, was identified in the ventral midline to the left of the caval foramen. The border of the incarcerated liver and the ring of the hernia were smooth and the adjacent pleura was intact. The liver was normal size and the herniated liver was normal colour and consistency and did not require resection. The hernia was adhered to the pleura, therefore the pleura was incised and the hernial contents were manually reduced to the abdominal cavity. A chest drain was placed through the left lateral thoracic wall and into the pleural cavity prior to herniorraphy. The edges of the diaphragm defect were not debrided and the defect was closed with 2 metric (3/0 USP) polydioxanone (Monosyn, B Braun, Tuttlingen, Baden-Württemberg) in a simple continuous pattern.

The pancreas, gastrointestinal tract and the incarcerated liver lobe were biopsied during surgery. Histopathology of the herniated liver biopsy was interpreted as mild periacinar hydropic degeneration, diffuse oedema and lymphangectasia; these changes were considered non specific and likely explained by venous obstruction and lymphatic stasis as a consequence of the herniation through the diaphragm. The pancreas and gastrointestinal tract histopathology results identified pancreatic islet amyloidosis as often seen with diabetes mellitus, mild interstitial lymphocytic pancreatitis and mild lymphoplasmacytic enteritis in the duodenum, jejunum and ileum.

The goal of the exploratory surgery was to investigate any underlying causes of the inappetence and poor diabetic control, and procedures performed allowed exclusion of significant liver pathology. In response to findings in the intestine and pancreas, pain relief was adjusted and cobalamin supplemented. The cat recovered uneventfully from the surgery and thoracic radiographs taken two days after surgery confirmed resolution of the pleuroperitoneal hernia. The cat's appetite improved after surgery resulting in discharge, with plans to monitor appetite and diabetic control at home. Two weeks after surgery, the cat's appetite and demeanor deteriorated again. Readmission was advised, but unfortunately the cat died three weeks after surgery at home. Necropsy was not performed.

Discussion

To the authors' knowledge this is the first report of the CT features of a pleuroperitoneal hernia (also referred to as a true diaphragmatic hernia) in a cat. In this case CT determined that the herniated portion of the liver was contiguous with the abdominal liver, as the post contrast arterial and venous phases highlighted the course of the branches of the left hepatic veins and left portal veins. These features resolved the origin of the soft tissue opacity mass identified radiographically as arising from herniated liver rather than a mass of pulmonary origin, which influenced the choice of surgical approach.

Congenital diaphragmatic hernias are due to diaphragmatic defects during embryonic development with the herniated contents remaining contained within the pericardium, cavum mediastinum or pleuroperitoneal sac² and include peritoneopericardial diaphragmatic hernias, hiatal hernias and pleuroperitoneal hernias. During embryonic development, the pleural and peritoneal cavities are separated as the primordial diaphragm forms by the fusion of the septum transversum, mesoesophagus and the pleuroperitoneal folds, ultimately closing the pleuroperitoneal canals.³ The final contribution to the diaphragm occurs later in foetal development as the thoracic cavity enlarges and myoblasts from the body wall migrate to the periphery of the diaphragm contributing to the lateral and dorsal muscular components.⁴ Pleuroperitoneal hernias develop during the separation of the pleural and peritoneal cavities as the pleuroperitoneal canal fails to close.³ Pleuroperitoneal hernias are rare in cats and are usually incidental findings without clinical signs.²

There are cases of pleuroperitoneal hernias described in the veterinary literature⁵⁻¹⁰ and two cases presented as short case reports.¹¹⁻¹² These cases illustrate the use of radiography, abdominal and transthoracic ultrasound and positive contrast peritoneography, in the assessment of suspected pleuroperitoneal hernia. Five of these case reports describe surgical confirmation and repair of a pleuroperitoneal hernia⁶⁻¹⁰ in cats presenting for unrelated causes and in each case the pleuroperitoneal hernia was considered an incidental finding, which is similar to this case report. The two short case reports which were also incidental findings were managed conservatively with one cat having repeat thoracic radiographs two years after the initial presentation with no progression of the radiographic features of the pleuroperitoneal hernia.¹² The experience in human medicine is that the advent of multidetector CT has enabled an increased detection of the prevalence of asymptomatic Bochladék's hernia in adults.¹³

In the current case, the ability of CT to identify the liver within the hernia and follow the hepatic and portal veins enabled a diagnosis of pleuroperitoneal hernia, clearly differentiating it from a pulmonary mass in either the accessory or caudal lung lobes. The CT findings had a direct influence on the choice of surgical approach (midline laparotomy rather than median sternotomy or lateral thoracotomy) in this case and enabled herniorrhaphy and biopsies of the gastrointestinal tract, pancreas and incarcerated liver to be achieved via a single surgical approach. Although the pleuroperitoneal hernia was considered incidental, as the cause of the ongoing inappetence was unknown, surgery was done to repair the hernia to remove any potential for pathology of the incarcerated liver as a contributing factor for inappetence or poor diabetic control.

In conclusion, whilst radiology, ultrasound and positive contrast peritoneography can provide an indication of caudal thoracic or diaphragmatic disease, there is a role for CT evaluation in the diagnostic evaluation of pleuroperitoneal hernia. This report of the CT features of pleuroperitoneal hernia, may enable accurate identification of pleuroperitoneal hernia and therefore enable the

planning of the appropriate surgical approach or potentially obviate the need for invasive diagnostic procedures such as surgery.

List of Author Contributions

Category 1

(a) Conception and Design

Author name (s) Anne Marie Rose, Cathy Beck

(b) Acquisition of Data

Author name (s) Anne Marie Rose, Stewart D. Ryan, Thurid Johnstone, Cathy Beck

(c) Analysis and Interpretation of Data

Author name (s) Anne Marie Rose, Stewart D. Ryan, Thurid Johnstone, Cathy Beck

Category 2

(a) Drafting the Article

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(b) Revising Article for Intellectual Content Author name (s) Anne Marie Rose, Stewart D. Ryan, Thurid Johnstone, Cathy Beck

Category 3

(a) Final Approval of the Completed Article Author name(s) Anne Marie Rose, Stewart D. Ryan, Thurid Johnstone, Cathy Beck

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7. Figure legends

Figure 1. Thoracic radiographs. (A) Right lateral recumbency: There is a soft tissue opacity in caudal thorax, with its broad base adjacent to the diaphragm. (B) Ventrodorsal projection: The caudal vena cava is seen, however the soft tissue opacity is midline and is not identified due to superimposition with the thoracic spine.

Figure 2. Computed tomography. Sagittal (A) and dorsal (B) image planes post contrast arterial phase after reconstruction with a smoothing algorithm and viewed in a soft tissue window. These images demonstrate the pleuroperitoneal hernia containing herniated liver and the continuation of the hepatic veins into the herniated portion of the liver.

Figure 3. Computed tomography. Sagittal (A) and dorsal (B) image plane after reconstruction with an edge enhancement algorithm and viewed in a lung window. (A) This image demonstrates the extension of the pericardial fat caudodorsally to the craniodorsal margin of the herniated liver (arrow). (B) This image demonstrates the caudal extension of the pericardial fat to the cranial margin of the herniated liver (arrow).

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