Pancreatic neoplasia in cats is rare and associated with a poor prognosis, but pancreatic nodular hyperplasia is a common incidental finding. The purpose of this study was to describe radiographic and ultrasonographic findings in cats with pancreatic neoplasia or nodular hyperplasia. Fourteen cats (age 3–18 years) were diagnosed with malignant pancreatic tumors: carcinoma/adenocarcinoma (n = 11), lymphoma (n = 1), squamous cell carcinoma (n = 1), and lymphangiosarcoma (n = 1). The most common radiographic findings were an abdominal mass or mass effect (6/6) and lack of serosal margin detail (4/6). On ultrasound, the most common finding was a focal pancreatic mass or nodule, with a size range from 0.4 cm to more than 7.0 cm (8/14). Lymphadenopathy (7/14) and abdominal effusion (7/14) were frequently seen. Five cats (age 10–16 years) with adenomatous/nodular hyperplasia had an abdominal mass or mass effect as the most common radiographic finding (3/3). On ultrasound, all cats had multiple hypoechoic nodules between 0.3 and 1.0 cm associated with the pancreas. Other common findings were pancreatic thickening (2/5), lymphadenopathy (2/5), and abdominal effusion (2/5). The only imaging finding unique to malignant pancreatic tumors was the presence of a single pancreatic nodule or mass exceeding 2 cm in at least one dimension (4/14). Although there was a tendency for neoplastic lesions to manifest as single larger lesions and for nodular hyperplasia to manifest as multiple smaller lesions, there was overlap of the imaging findings in both entities. Radiographs and ultrasound can complement but not replace cytology and histopathology in the diagnosis of feline pancreatic neoplasia. Veterinary Radiology & Ultrasound, Vol. 48, No. 1, 2007, pp 45–50.

Key words: cat, pancreas, pancreatic neoplasia, pancreatic nodular hyperplasia, ultrasound.

Introduction

EXOCRINE PANCREATIC TUMORS are rare in cats, with an incidence less than 0.5%.1–3 Pancreatic adenocarcinoma is the most common tumor type.4 Few pancreatic stromal tumors, such as sarcomas, have been reported.1 Pancreatic adenomas are occasionally found as an incidental finding.5 The diagnosis of exocrine pancreatic neoplasms is challenging, because clinical signs and hematologic results are nonspecific or may be normal.5,6 Possible radiographic abnormalities with a feline pancreatic tumor are abdominal effusion and a mass effect.7 Localization of the mass to the pancreas is usually impossible.5 On ultrasound, abdominal effusion, nodules or masses associated with, or in the vicinity of, the pancreas, or signs of extrahepatic biliary obstruction may be seen.5,7 These changes overlap with ultrasonographic features of pancreatitis in cats which include hypoechogenicity of the pancreatic parenchyma, hyperechoic peripancreatic mesentery, peritoneal effusion, pancreatic enlargement, a pancreatic mass, or dilation of bile ducts.8–11 The accuracy of ultrasound in the diagnosis of pancreatic tumors in cats is unknown. Sensitivity and specificity of ultrasound for the detection of pancreatic tumors in humans were determined to be as high as 90% and 98.8%, respectively.12 The major ultrasonographic differential diagnosis for pancreatic carcinoma in humans is focal pancreatitis, since both entities can appear as a focal hypoechogenic area with or without pancreatic enlargement.13 The sensitivity for the detection of pancreatic tumors in dogs has been reported to be 19% for radiographs and 75% for ultrasound.14 Potential pitfalls for the imaging diagnosis of pancreatic neoplasms in dogs include masses arising from adjacent structures invading or bordering the pancreas, abnormal lymph nodes in close proximity to the pancreas, overlap between ultrasonographic signs of pancreatitis and pancreatic neoplasia and a similar ultrasonographic appearance of benign and malignant pancreatic lesions. Similar difficulties are likely to be encountered in cats.

Pancreatic nodular hyperplasia is a common incidental finding in old dogs and cats.15 In one study, changes
compatible with nodular hyperplasia were seen in 12/57 cats. Evidence of pancreatic nodular hyperplasia was found in 80.2% of dogs, with a significant positive correlation with age. Imaging findings in pancreatic nodular hyperplasia in cats have, to our knowledge, not been described. The purpose of our study was to describe imaging features in feline pancreatic neoplasia and nodular hyperplasia.

**Materials and Methods**

Cats were identified by search of the radiology and pathology case logs of TCSVM, for the period 1999 through 2004, for cats with a cytologic or histopathologic diagnosis of pancreatic neoplasia or nodular hyperplasia. Inclusion criteria were a complete radiographic and/or ultrasonographic examination of the abdominal cavity, a definite diagnosis by means of ultrasound-guided fine-needle aspiration or biopsy, surgical biopsy or necropsy within 3 months following the radiographic and/or ultrasonographic examination, and the confirmation of pancreatic neoplasia or nodular hyperplasia after review of the samples. Information on signalment and results of fine needle aspirates or biopsies were obtained from the medical records. Radiographs, still images and videotapes of the ultrasonographic examinations and radiology reports were reviewed. The imaging documents were reviewed by a radiology resident (S.H.) and a board-certified radiologist (D.G.P.). The following information was recorded from the radiographs: serosal margin detail; presence and origin association of abdominal masses; other abnormalities associated with the abdominal cavity; abnormalities associated with the thorax. The following information was recorded from the ultrasonographic examinations: presence of abdominal effusion; presence, distribution, size, and echogenicity of pancreatic lesions; presence of lesions and abnormalities in the vicinity of the pancreas; abnormalities associated with the mesentery; lymphadenopathy; evidence of extrahepatic biliary obstruction; other abnormalities.

The histopathologic and cytologic samples were reviewed by a board-certified pathologist (J.H.K.). In instances of questionable or inconclusive diagnoses, additional immunohistochemical stains were performed.

**Results**

The search revealed 17 cats diagnosed with malignant pancreatic tumors and five with pancreatic nodular hyperplasia. One cat with a presumptive diagnosis of pancreatic lymphoma was excluded, as tissue samples were not available for review. One cat with a previous diagnosis of pancreatic carcinoma and concurrent nodular hyperplasia was excluded, as there was no evidence of neoplasia based on the samples available for review. A third cat with a previous presumptive diagnosis of pancreatic lymphoma was excluded, as immunohistochemical stains revealed a mixture of about 75% CD3-positive T-cells and cd79a-positive B-cells, consistent with a nonneoplastic infiltrate. Therefore, 19 cats met the inclusion criteria.

**Cats with Malignant Pancreatic Tumors**

Fourteen cats with a mean and median age of 12 years (range 3–18 years) were diagnosed with a malignant pancreatic tumor. There were 10 domestic Shorthair cats, two domestic Longhair cats, one Maine Coon and one mixed breed cat. Five cats were neutered male, nine were neutered female. The diagnosis was achieved through ultrasound-guided or surgical biopsy of the pancreas (9/14), necropsy (4/14) and fine needle aspiration of the pancreas, and liver biopsy (1/14). In one of the cats diagnosed at necropsy, metastases of pancreatic adenocarcinoma were found in the liver, while the primary site within the pancreas could not be identified. The most common tumor type was pancreatic carcinoma/adenocarcinoma (11/14). Other tumor types were squamous cell carcinoma (1/14), lymphosarcoma (1/14), and lymphangiosarcoma (1/14). Immunohistochemical stains were performed in the cat with lymphoma, which revealed homogenous and CD3-positive infiltrates throughout the pancreas, consistent with T-cell lymphoma. Immunohistochemical stains were also performed to confirm a carcinoma which was difficult to classify due to poor differentiation.

Abdominal radiographs were available for review in six cats, all of which had radiographic abnormalities. An abdominal mass or mass-effect was the most common finding. In three cats, the masses were associated with the liver or spleen. One cat had a 2 cm mass lesion associated with the cranial mid abdomen between stomach and kidneys (Fig. 1). One cat had a mass of uncertain origin in the cranioventral abdomen. In one cat, a 5.0 × 3.5 cm bilobed

![Fig. 1. Lateral radiograph of the cranial abdomen in a cat with pancreatic squamous cell carcinoma. There is an ovoid mass effect between the cranial pole of the right kidney and the gastric fundus (arrows).](image-url)
mass was seen associated with the left cranial abdomen, summating with the left kidney (Fig. 2). Decreased serosal margin detail, consistent with abdominal effusion was seen in four cats, and one cat had an irregular mottled opacity throughout the peritoneal cavity, consistent with carcino-
matosis (Fig. 3). Other abnormalities on abdominal radiographs were a fluid-filled colon (1/14) and multifocal spondylosis deformans (1/14). Thoracic radiographs were available for review in 10 cats. One cat had an enlarged sternal lymph node, and in four cats there was generalized cardiomegaly. None of the cats had evidence of pulmonary metastatic disease.

Abdominal ultrasound was performed in all patients. A focal pancreatic mass or nodule was the most common abnormality (8/14) (Fig. 4). These lesions were hypoechoic (7/8) or mixed echogenic (1/8), and areas of distal sound beam attenuation consistent with mineralization was noted in 3/14 cats. Size ranged between 0.4 × 1.0 cm and more than 7.0 × 3.0 cm. Six of the cats in this group had carcinomas/adenocarcinomas. In four cats, the size of the mass exceeded 2 cm in at least one dimension. The cat with T-cell lymphoma had a 1.0 × 1.8 cm hypoechoic nodule at the level of the pancreatic body, and the cat with pancreatic squamous cell carcinoma had a 1.0 × 2.0 cm nodule at the level of the duodenal papilla. In three cats with pancreatic carcinoma/adenocarcinoma, the pancreas had diffuse irregular thickening, with multiple hypoechoic nodules (Fig. 5). In one cat with pancreatic adenocarcinoma the pancreas was within normal limits ultrasonographically except

Fig. 2. Ventrodorsal radiograph of the left cranial abdomen in a cat with pancreatic carcinoma. There is a bilobed 5.0 × 3.5 cm soft tissue mass superimposed over and summating with the left kidney (arrows).

Fig. 3. Lateral radiograph of the abdomen in a cat with pancreatic adenocarcinoma and peritoneal carcinomatosis. There is mottled loss of serosal margin detail throughout the peritoneal cavity. The liver is enlarged.

Fig. 4. Ultrasonographic image of a mass (carcinoma) associated with the left limb of the pancreas (same cat as Fig. 2).

Fig. 5. Pancreatic adenocarcinoma. There is irregular nodular thickening of the left lobe of the pancreas (between cursors), and the pancreas is surrounded by hyperattenuating fat.
for a dilated pancreatic duct (0.4 cm diameter). In the cat with lymphangiosarcoma, no ultrasonographic abnormalities were seen. One cat had a more than 10 cm mixed echogenic cystic mass associated with the mid to cranial abdomen, which was of uncertain origin (Fig. 6). This was diagnosed as pancreatic cystadenoma and cystadenocarcinoma, respectively, based on surgical biopsies obtained at two occasions. Other ultrasonographic findings in this group were abdominal lymphadenopathy (7/14), abdominal effusion (7/14), mesenteric nodules (4/14), and peri-pancreatic hyperattenuating fat (4/14) (Fig. 5). Two cats had extrahepatic biliary obstruction (Fig. 7). Abnormalities associated with other organs were commonly seen and included hepatomegaly (4/14), hepatic nodules or masses (7/14), thickening of the gall bladder wall (1/14), splenomegaly (2/14), splenic nodules or masses (2/14), changes compatible with chronic renal disease (5/14), fluid-filling and hypomotility of the intestinal tract (1/14), and intestinal wall abnormalities (1/14). In one cat, pleural effusion was seen through the diaphragm.

Cats with Pancreatic Nodular Hyperplasia

Five cats with a mean and median age of 14 years (range 10–16 years) were diagnosed with pancreatic adenomatous/nodular hyperplasia. There were three domestic Shorthair cats, one domestic Longhair cat and one Maine Coon cat. Three cats were neutered male, two were neutered female. The diagnosis was achieved through surgical biopsy of the pancreas (3/5) or necropsy (2/5). In one cat, ultrasound-guided fine needle aspiration had been attempted before biopsy, but the samples were nondiagnostic. The histologic diagnosis was adenomatous (macronodular) hyperplasia in three cats and micronodular hyperplasia in two cats.

Abdominal radiographs were available for review in three cats, all of which had radiographic abnormalities. An abdominal mass or mass-effect was the most common finding. In one cat, the mass was associated with the liver. One cat had a rounded 2 cm mass lesion associated with the cranial midabdomen between stomach and kidneys (Fig. 8), and one cat had a 3 cm mass effect associated with the cranioventral abdomen. In one cat extensive cholelithiasis and pancreatolithiasis were noted (Fig. 8). Two cats had an abnormally fluid-filled intestinal tract. In all cats serosal margin detail was adequate. Thoracic radiographs were available for review in three patients. One cat had attenuation of the cardiovascular structures, consistent with dehydration. None of the cats had evidence of pulmonary metastases.

Fig. 6. Ultrasonographic image of a large (more than 10 cm diameter) mixed echogenic and cystic mass associated with the cranial abdomen, which was diagnosed as pancreatic cystadenocarcinoma.

Fig. 7. Ultrasonographic image of a pancreatic squamous cell carcinoma. The pancreatic mass (arrows) measures 2 × 1 cm and is located at the level of the duodenal papilla (DUOD, duodenum), resulting in obstruction of the common bile duct (CBD; same cat as Fig. 1).

Fig. 8. Lateral radiograph of the cranial abdomen in a cat with pancreatic nodular hyperplasia. There is an ovoid mass lesion between the cranial pole of the right kidney and the gastric fundus (arrows). There is also mineralization of the biliary system (cholelithiasis) and hepatomegaly.
Abdominal ultrasound revealed multifocal abnormalities associated with the pancreas in all cats, with multiple hypoechoic nodules (5/5) and pancreatic enlargement (2/5) (Fig. 9). The nodules measured between 0.3 and 1.0 cm in diameter, and the pancreas measured up to 2 cm in thickness. Other ultrasonographic findings were abdominal lymphadenopathy (2/5), abdominal effusion (2/5), and mesenteric nodules (1/5). Peripancreatic hyperattenuating fat was not seen in any of the cats. In two cats, there was dilation of the pancreatic duct (0.45 and 0.7 cm diameter, respectively). One cat had extensive cholelithiasis and pancreatic duct obstruction. Two cats had extrahepatic biliary obstruction. Abnormalities associated with other organs were commonly seen and included hepatomegaly (2/5), hyperechogenicity of the liver (1/5), hepatic cysts (1/5), renal abnormalities (2/5), abdominal masses (1/5), and intestinal wall abnormalities (2/5).

Discussion

The most common radiographic features of pancreatic neoplasia in this study were an abdominal mass or mass effect and decreased serosal margin detail suggesting abdominal effusion, which is accordance with previous reports. An abdominal mass or mass effect was also the most common finding in cats with pancreatic nodular hyperplasia.

The only ultrasonographic feature unique to pancreatic malignant tumors was the presence of a single pancreatic nodule or mass exceeding 2 cm in at least one dimension, which was seen in 4/14 patients. Although the largest distinct hyperplastic nodules did not measure more than 1 cm in maximum diameter, it was difficult to distinguish some of them accurately from surrounding pancreatic parenchyma, which measured up to 2 cm wide. Pancreatic or peripancreatic nodules or masses were previously reported as ultrasonographic indicators of feline pancreatic tumors, but measurements of these lesions were not provided. In the current study, cats with pancreatic neoplasia or hyperplasia shared common ultrasonographic features, including multifocal pancreatic nodules, pancreatic enlargement, and extrahepatic biliary obstruction. Although there was a trend for multiple nodules to represent benign lesions, this feature was also seen in three cats with pancreatic adenocarcinomas. Peripancreatic lymphadenopathy was commonly seen in cats of both groups. Lymphatic drainage of the pancreas is provided by splenic, hepatic, pancreaticoduodenal and jejunal lymph nodes, all of which are also involved in the drainage of other abdominal organs. As concurrent abnormalities of liver, spleen, and intestinal tract were a common finding in cats of both groups, it was impossible to attribute lymphadenomegaly to abnormalities of the pancreas only. Abdominal effusion was also noted in cats of both groups, which may or may not be related to pancreatic disease.

There are several limitations to this study. Owing to the low number of cats with proven nodular hyperplasia, a determination of sensitivity and specificity of individual imaging features in distinguishing benign from malignant disease was not possible. A maximum of 3 months between imaging and diagnosis by means of cytology or histopathology was chosen as an inclusion criterion. An extension of the time frame might have led to an increase in the number of cats with nodular hyperplasia. Additionally, cats with pancreatitis and cats without pancreatic disease were not included in this study, preventing evaluation of
the incidence of feline pancreatic disease in our population and preventing determination of sensitivity and specificity of radiography and ultrasonography for the diagnosis of pancreatic neoplasia and nodular hyperplasia in cats.

While carcinoma/adenocarcinoma was the most common tumor type in this study, which is in accordance with the literature, there were also three unusual tumor types (squamous cell carcinoma [likely of pancreatic duct origin], lymphoma and lymphangiosarcoma). These might represent rather disseminated or metastatic lesions or tumors invading the pancreas from adjacent structures than true primary pancreatic tumors. However, since these tumors were associated with the pancreas both on imaging and surgery or necropsy, we included them in the study.

In two cats with a pancreatic tumor, the pancreas was considered normal or nearly normal based on the ultrasonographic examination. While in one cat there were only three days between the ultrasonographic examination and the final diagnosis, almost 6 weeks elapsed in the second cat. The possibility has to be considered, that a repeat examination of the pancreas closer to the cytologic/histopathologic examination might have revealed pancreatic abnormalities not seen during the initial examination.

In conclusion, imaging findings in nodular hyperplasia of the feline pancreas are similar to changes seen with malignant pancreatic neoplasms. Although there was a trend for malignant neoplasms to appear as a single larger lesion and for hyperplastic nodules to appear as smaller nodules, radiographs and ultrasound can complement but not replace cytology and histopathology in the diagnosis of feline pancreatic neoplasia.

REFERENCES