Alimentary-associated carcinomas in five Vietnamese potbellied pigs

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Case Description—Five Vietnamese potbellied pigs were evaluated for abdominal distress that had not responded to medical treatment (4 pigs) or a draining tract of the cranial abdomen of unknown duration (1 pig).

Clinical Findings—Clinical signs in the pigs included anorexia, vomiting, and constipation. Physical examination revealed a palpable abdominal mass in all pigs. Radiography revealed distended loops of small intestine in 2 pigs.

Treatment and Outcome—Three pigs were treated successfully with wide-margin excision of the abdominal masses, and 2 were euthanized. Primary tumors were diagnosed at necropsy or through histologic evaluation of biopsy specimens obtained during surgery. Types of tumor included cholangiocellular carcinoma, transmural gastric carcinoma, small intestinal adenocarcinoma, metastatic hepatocellular carcinoma, and carcinoma. The tumors involved the stomach, small intestine, spiral colon, liver, and gall bladder. All 3 surgically treated pigs survived at least 9 months after surgery.

Clinical Relevance—Although rare, neoplasia of the alimentary system should be considered among the differential diagnoses for potbellied pigs with signs of abdominal distress. Wide-margin excision of the neoplastic tissue may result in a good outcome in affected pigs. (J Am Vet Med Assoc 2009;235:1336–1341)

A 14-year-old 54-kg (119-lb) spayed female Vietnamese potbellied pig (pig 1) was referred to the James L. Voss Veterinary Teaching Hospital at Colorado State University for evaluation of a draining tract of the cranial abdomen of unknown duration. A pyloric emptying disorder had been diagnosed in the pig 2 years previously, but the pig did not have clinical signs associated with abnormal pyloric emptying when examined at the teaching hospital. Ultrasonographic examination of the abdomen revealed a well-marginated, thick-walled structure extending from the abdominal wall to the liver parenchyma. Within the liver parenchyma, an enlarged area with a hypoechoic to anechoic center was detected. The center of the area appeared to swirl when ballottement was performed and had increased blood flow at its periphery, compared with blood flow elsewhere within the adjacent parenchyma. The gall bladder could not be identified. A presumptive diagnosis of liver abscess with a cutaneous draining tract was made, and surgical removal was planned for 1 week later. Hematologic and biochemical abnormalities detected at the time of this initial evaluation included anemia (PCV, 23%; reference limits, 32% to 50%) and hyperglobulinemia (serum globulins concentration, 4.2 g/dL; reference limits, 1.5 to 3.5 g/dL).

The following week, the pig was returned for surgery. A celiotomy was performed via a routine ventral midline approach to the abdomen, revealing a fibrous mass measuring approximately 15 × 5 cm, which was adhered to the body wall at the site of the draining tract and extended through the liver. Grossly normal gall bladder tissue could not be identified. The cystic duct was ligated at the site of its attachment to the mass. The mass was removed but was controlled with metoclopramide (0.2 mg/kg [0.09 mg/lb], PO, q 12 h) and small feedings; vomiting resolved 2 days later.

Histologic evaluation of the gall bladder revealed a mass of closely packed to loosely arranged clusters and acini of neoplastic gall bladder epithelial cells that infiltrated the surrounding tissue (Figure 1). Marked proliferation of dense fibrous connective tissue appeared to have developed around the mass. The adjacent liver had evidence of diffuse collapse of lobules with dense fibrous tissue. The final diagnosis was cholangiocellular carcinoma and moderate diffuse chronic cholangitis. Surgical margins were not evaluated.

A follow-up ultrasonographic examination of the liver was performed 8 months after surgery. At that time, there was no evidence of additional neoplastic nodules, and the overall size of the liver was unremarkable. The pig was judged systemically healthy, although the owner reported it was intolerant of foods containing a high concentration of fat and had lost approximately 2.3 kg (5 lb) since the surgery: Although the pig was evaluated 3 additional times because of signs of inappetence and lethargy (64, 82, and 84 months after...
surgery), a diagnosis of small intestinal disease was made, and the condition improved after treatment with a combination of antimicrobials (amoxicillin; 7.5 to 10 mg/kg [3.5 to 4.5 mg/lb], PO, q 12 h), anti-inflammatory drugs (prednisone; 0.4 mg/kg [0.2 mg/lb], PO, q 12 h), prokinetic agents (cisapride; 0.1 mg/kg [0.045 mg/lb], PO, q 12 h), and antiemetic drugs (metoclopramide; 0.2 mg/kg, PO, 30 minutes before meals).

Eighty-five months after surgery, the pig was returned to the teaching hospital for evaluation for a 3-day history of anorexia and oral and nasal hemorrhage that had worsened during the previous 24 hours. Immune-mediated thrombocytopenia was suspected, but diagnostic testing was not pursued. The owner elected to euthanize the pig and declined a necropsy.

A second Vietnamese potbellied pig (16 years old; 45 kg [99 lb]; pig 2) was evaluated for a 2-week history of diarrhea, vomiting, anorexia, and dehydration. The pig's condition had improved somewhat after treatment at home with orally administered fluids, but on the day of evaluation, it had become weak and could not stand. Initial physical examination revealed dehydration (estimated at 10%), pale mucous membranes with a capillary refill time > 3 seconds (reference limit, < 2 seconds), and a rectal temperature of 36.1°C (97°F). A firm mass was palpated in the midabdomen, and ultrasonographic examination revealed the mass was homogenous, multilobulated, and surrounded by free fluid of mixed echogenicity. Abdominocentesis yielded frank blood. Hematologic abnormalities detected during the initial evaluation included anemia (PCV, 18%) and leukocytosis (23.2 $\times$ 10$^3$ WBCs/µL; reference limits, 11.0 $\times$ 10$^3$ WBCs/µL to 22.0 $\times$ 10$^3$ WBCs/µL) with a regenerative shift to the left (19 $\times$ 10$^3$ segmented neutrophils/µL, 900 band cells/µL, and 500 metamyelocytes/µL).

An emergency exploratory celiotomy was performed on the basis of results from the clinical evaluation. The immediate surgical finding was copious free blood and an enlarged and ruptured spleen, which was removed with the aid of a stapling device. Because of extensive blood loss from the ruptured spleen, a bovine hemoglobin product was administered (10 mL/kg, IV). The abdomen was thoroughly lavaged following removal of the spleen, and the remainder of the abdomen was routinely explored. A mass was palpated in the gastric fundus near the pylorus. Gastrotomy revealed a well-circumscribed soft tissue mass that was 3 cm in diameter and attached to the gastric mucosa by a vascular pedicle that was 0.5 cm in diameter. The mass was removed at its attachment with the aid of a stapling device, and the gastrotomy incision was routinely closed. The remainder of the gastrointestinal tract was unremarkable. The gastric mass and multiple specimens obtained from the spleen were submitted for histologic evaluation. A CBC performed before the pig was discharged from the hospital (5 days after surgery) revealed a platelet count within reference limits and a strong regenerative response to anemia. At that time, the pig was eating, drinking, urinating, and defecating remarkably.

Histologic evaluation of the gastric mass revealed a highly infiltrative, poorly demarcated mass composed of ill-defined acini and tubular structures as well as lobules and nests of pleomorphic epithelial cells embedded within fibrous connective tissue (Figure 2). Neoplastic cells extended transmurally individually and in small nests from the mucosa to the muscularis and were also detected within blood vessels. Supporting stroma contained marked lymphocyte infiltration. These findings were consistent with a transmural gastric carcinoma with metastasis to the local vasculature. No evidence of neoplasia was detected in spleen specimens.

The pig was not returned to the teaching hospital for a follow-up examination; however, the owner was contacted by telephone 24 months after surgery. At that time, the pig was reportedly healthy with no evidence of tumor recurrence or metastasis.

A 12-year-old 42-kg (92.4-lb) sexually intact female Vietnamese potbellied pig (pig 3) was evaluated because of a 1-month history of a lower than typical appetite and a 1-week history of anorexia. The pig had...
been vomiting 1 to 2 times/wk during the month preceding the evaluation and had a 1-year history of weekly seizures. No specific treatments had been administered by the owners for either condition.

During the initial examination, the pig had a grand mal seizure of approximately 60 seconds in duration. A CBC and serum biochemical analysis were performed, revealing an unremarkable total WBC count with a shift to the left (800 band cells/µL). A mild anemia was also evident (PCV, 29%) as well as a mild increase in serum activity of alanine aminotransferase (103 U/L; reference limits, 23 to 83 U/L).

Abdominal radiographs revealed a distended stomach filled with fluid and gas and at least 2 segments of severely gas-distended small intestine. Most of the small intestine and colon appeared to be unremarkable in dimension but were displaced caudally and dorsally by the distended segments. These findings were interpreted as consistent with a partial bowel obstruction, and treatment with metoclopramide (0.4 mg/kg, IV, q 8 h) and cisapride (0.5 mg/kg [0.23 mg/lb], PO, q 8 h) was initiated to promote gastrointestinal motility. Intravenous administration of fluids (150-mL bolus, q 2 h) was also initiated, as was treatment with ceftriaxone (4.4 mg/kg [2 mg/lb], IV, q 12 h). Several warm water and soap enemas were administered. Two additional, less severe seizures were observed during hospitalization; however, the pig recovered from all seizures without treatment, and the cause of the condition was not pursued at the owner's request. The dose of metoclopramide was reduced to 0.2 mg/kg after 24 hours because of concern that the high dose initially administered was lowering the pig’s seizure threshold. During 3 days of hospitalization, the pig’s condition improved. Radiographs obtained 3 days after admission revealed that the gastric distention had resolved and the small intestinal distention had improved but not resolved. Because the pig was responding to medical treatment while hospitalized, exploratory celiotomy was not pursued.

The prognosis was deemed fair, depending on continued response to treatment. Three days after discharge from the hospital, the pig was euthanized at home because of worsening of the owner’s concern that the high dose initially administered was lowering the pig’s seizure threshold. During 3 days of hospitalization, the pig’s condition improved. Radiographs obtained 3 days after admission revealed that the gastric distention had resolved and the small intestinal distention had improved but not resolved. Because the pig was responding to medical treatment while hospitalized, exploratory celiotomy was not pursued. The prognosis was deemed fair, depending on continued response to treatment.

Three days after discharge from the hospital, the pig was euthanized at home because of worsening of clinical signs, including increased frequency and severity of seizures, and was returned for postmortem examination. The examination revealed a firm, white mass that was 1.5 cm in diameter protruding into the stomach and obstructing approximately 90% of the jejunum’s diameter. Oral to the mass, the jejunum was moderately distended. The brain and brainstem appeared grossly unremarkable. Results of the necropsy and subsequent histologic evaluation of the mass were consistent with a diagnosis of small intestinal adenocarcinoma.

A 15-year-old 46-kg (101.2-lb) castrated male Vietnamese potbellied pig (pig 4) was evaluated for a neck mass that was 1.5 cm in diameter protruding into the trachea and confirmed to be unremarkable. Although the pig was judged thin and the owner reported gradual weight loss during the preceding week to months. Palpation of the throat revealed no abnormalities. During palpation of the abdomen, a large, firm, multilobulated mass was detected in the cranial abdomen. Ultrasonographic evaluation revealed the mass had mixed echogenicity with some cystic structures and areas of mineralization. These findings suggested the mass arose from the liver.

Similar to findings in the other pigs, results of a CBC indicated leukocytosis with a shift to the left. Serum biochemical analysis revealed hyperproteinemia (total protein concentration, 9.7 g/dL; reference limits, 6 to 8 g/dL), hyperglobulinemia (globulins concentra-

Figure 3—Thoracic radiograph (right lateral view; head is toward the left) of a Vietnamese potbellied pig (pig 4) revealing metastasis of a hepatocellular carcinoma throughout the lungs. Discrete nodules of soft tissue opacity measuring up to 18 mm in diameter can be seen (arrowheads). Mineralized nodules within the primary liver mass are also evident (arrow).
An 11-year-old 36-kg (79.2-lb) spayed female Vietnamese potbellied pig (pig 5) was evaluated at the teaching hospital for a 7-day history of failure to defecate. Treatment with metoclopramide was initiated at home with no improvement. Two months previously, the pig had 6 teeth extracted; since that time, it had signs of inappetence and mild constipation. Warm-water enemas and orally administered mineral oil had resolved the mild constipation until 1 week prior to admission to the teaching hospital. The pig had a history of 2 abdominal surgeries: an elective spay at < 6 months of age and an emergency exploratory celiotomy after evaluation for signs of acute abdominal pain and a rectal prolapse at 1 year of age.

Physical examination revealed the pig was bright, alert, and responsive. Abdominal radiographs revealed marked gaseous distention throughout the gastrointestinal tract, with craniocentral displacement of the cecum. Treatment was initiated with isotonic fluids (3.3 mL/kg/h [1.5 mL/lb/h], IV), famotidine (1 mg/kg [0.45 mg/lb], IV, q 12 h), cisapride (0.5 mg/kg, PO, q 8 h), and metoclopramide (0.4 mg/kg, PO, q 12 h), but when abdominal radiographs were obtained 24 hours later, they revealed no improvement in the appearance of the gastrointestinal tract. An exploratory celiotomy was consequently recommended. Results of a preoperative hematologic analysis were unremarkable except for a mild anemia (PCV, 29%).

During surgery, multiple adhesions were evident between the body wall and the spiral colon, some of which involved the simple, continuous line of nylon sutures remaining from the exploratory surgery performed 10 years earlier. Additional exploration revealed a grossly enlarged spleen and markedly gas-distended loops of bowel, which started in the midjejunum and extended into the spiral colon. A 5 x 5-cm mass was palpated between 2 loops of spiral colon, at the junction between the centrifugal and centripetal loops; it appeared to have caused stenosis of the colon and chronic dilation of the oral segment. This mass was deep to and intimately associated with the mesentery of the spiral colon. Consequently, the affected loops of spiral colon and the mass were resected en bloc (Figure 4). A side-to-side anastomosis of the spiral colon was performed with the aid of stapling equipment. The only other remarkable finding during the exploratory surgery was a mottled appearance of the spleen.

Punch-biopsy specimens were obtained from the spleen and were later submitted along with the colon mass for histologic evaluation. The pig was discharged from the hospital 3 days after surgery. Histologic evaluation of the mass revealed it was a lymph node with typical lymph-node architecture effaced by neoplastic cells arranged in small nests and acini. The encapsulated mass was surrounded by abundant granulation tissue with a moderate number of lymphocytes. There were no histologic abnormalities within the resected loop of spiral colon. The neoplastic mass was morphologically consistent with an adenocarcinoma of gastrointestinal origin, but no definitive cell of origin could be identified. A final diagnosis of carcinoma with marked desmoplasia was made. There was no evidence of neoplastic cells in the spleen biopsy specimen.

Although the pig was not returned to the teaching hospital for a follow-up examination, the owner was contacted by telephone 9 months after surgery. At that time, the pig was reportedly healthy, with no evidence of tumor regrowth or metastasis.

**Discussion**

Neoplasia of gastrointestinal or hepatobiliary origin in pigs is infrequently reported, and most of the reports concern domestic breeds in which the lesions were detected at slaughter or as incidental findings at necropsy. To our knowledge, alimentary-associated tumors in Vietnamese potbellied pigs have not been reported. This breed represents a small but important portion of pet livestock patients in many practices, and there is little published information regarding the incidence or clinical manifestations of neoplasia of any type in this population. We report 5 geriatric Vietnamese potbellied pigs with alimentary-associated carcinoma or adenocarcinoma, which were evaluated at our hospital between January 2000 and June 2008. These pigs represented 1% of the total potbellied pigs evaluated at our hospital during this period (total of 438 visits in 8 years) and 12% of pigs that were evaluated for nonspecific signs of abdominal distress.

The most commonly reported types of neoplasms in domestic pigs are lymphoma, melanoma, and embryonal nephromas, but even these types are uncommonly detected in large abattoir or diagnostic laboratory surveys. One survey of federally inspected slaughter facilities resulted in the identification of tumors in 28 domestic pigs during a 2-year period. Of these, 13 tu-
mors were embryonal nephromas, 9 were lymphomas, and 3 were melanomas. A similar 5-year survey\(^2\) resulted in the identification of tumors in 32 pigs, including 11 embryonal nephromas and 12 lymphomas (data on melanoma detection were excluded). Overall incidence of tumor detection in the 2 aforementioned surveys were 1/35,000 pigs\(^2\) and 1/25,000 pigs, respectively. By comparison, the incidence of tumor detection in cattle in the first survey\(^3\) was 1/1,500 cattle, even when data on detection of ocular squamous cell carcinoma, the most commonly identified tumor in cattle at slaughter during the survey period, were excluded. In neither of these abattoir surveys were tumors of the liver or intestines identified. It has been suggested that the reason for the low incidence of neoplasia in pigs is that most are slaughtered before they reach geriatric age, but to our knowledge, this hypothesis has never been objectively evaluated. In the United States, Vietnamese potbellied pigs are considered companion animals and therefore live long enough to develop diseases associated with advancing age.

A few reports of neoplasia in Vietnamese potbellied pigs exist, including 2 pigs with uterine leiomyomas\(^6\), 1 pig with metastatic endometrial adenocarcinoma\(^7\); 1 pig with metastatic oral squamous cell carcinoma, uterine adenocarcinoma, and hepatocellular adenoma\(^8\); and 1 pig with hepatocellular carcinoma and suspected splenic hemangiosarcoma\(^9\). The aforementioned pigs ranged in age from 8 to 16 years at the time of diagnosis. The youngest pig in the present clinical report was 11 years old. These findings support the supposition that neoplasia emerges as an important disease in Vietnamese potbellied pigs of middle to old age.

Primary liver tumors in domestic pigs have been reported only rarely, although lymphoma of the liver as a secondary or metastatic tumor is fairly common.\(^{10,11}\) Aflatoxins fed at 1 ppm reportedly cause liver cancer in pigs,\(^13\) but there was no evidence of exposure to any toxins in the pig with hepatocellular carcinoma reported here. An abattoir study\(^6\) of tumors in pigs resulted in the identification of primary liver-cell tumors in 4 of 139 (2.9%) tumors. Two of the tumors were detected in pigs < 6 months of age, and the other 2 were detected in adult pigs. Three of the 4 lesions appeared to be solitary, although multiple neoplastic nodules were detected in the liver of 1 adult pig.\(^4\) Solitary, well-differentiated hepatocellular carcinomas have also been detected in a 6-month-old male domestic pig\(^1\) and a 10-year-old male castrated Vietnamese potbellied pig.\(^11\) In none of the aforementioned pigs were metatases detected. In contrast, metastases to the local lymph nodes, spleen, peritoneum, omentum, endocardium, and lungs were detected in a 2-year-old large white Yorkshire sow in which primary hepatocellular carcinoma had been diagnosed.\(^{13}\) These findings are similar to those in pig 4 of the present report, in which multiple neoplastic nodules were detected in the lungs. The proportion of hepatocellular carcinomas that result in metastases in other animal species ranges from 23% to 61%.\(^{13}\) It is possible that pigs have a similar likelihood of developing metastatic hepatocellular carcinomas, although additional research is needed to evaluate that likelihood. It is impossible to determine whether early surgical intervention would have prolonged the life of pig 4, but in dogs, survival for 1 year is possible after surgical removal of affected liver lobes.\(^{13}\)

To our knowledge, there has been only 1 other report\(^9\) of a gallbladder tumor in a pig. That pig, a 3-year-old domestic sow, developed a tumor involving much of the mucosa of the gall bladder; the diagnosis was papillary adenocarcinoma.\(^3\) In contrast, the tumor that developed in pig 1 in the present report was identified as cholangiocellular carcinoma, but was not papillary. No metastases were evident at the time of surgery in pig 1, and excision was curative, with the pig surviving 7 years after surgery. Although a necropsy was declined, the clinical signs that ultimately led to euthanasia of that pig were not consistent with those of the original neoplastic disease, and the 2 conditions were not likely related.

Although in the present report we describe 3 primary intestinal tumors, such tumors have otherwise been only rarely reported. Gastric carcinomas, such as that described in pig 2, are most common in dogs, but an affected domestic pig has been reported.\(^13\) In contrast to humans, in whom gastric ulceration caused by Helicobacter pylori has been linked to an increased risk of gastric carcinoma,\(^13\) there does not seem to be a similar link between gastric- ulcer disease and malignant neoplasia in pigs.\(^15\) Although there was microscopic evidence of transmural metastasis with vascular invasion in pig 2, the pig survived for at least 2 years after surgery, with no evidence of local recurrence or distant metastasis of the tumor. This finding is similar to the survival rate in dogs with surgically removed gastric carcinomas (12 to 35 months).\(^13\)

Adenocarcinoma of the small intestine in pigs has only been investigated in 1 survey\(^1\) of intestinal tumors detected at slaughter. In that survey, 5 domestic sows had tumors that were located in the middle or distal third of the jejunum and were annular, leading to stenosis of the intestine at the affected site. In 3 of the pigs, the tumors had metastasized to the regional lymph nodes, and in 1 of those 3, distant metastases were detected in the lungs. The tumor detected in pig 3 of the present report was similar to tumors detected in the survey\(^1\) in that it was located in the distal jejunum and protruded into the lumen, causing obstruction. However, there was no evidence of metastasis in pig 3. No report of excision of this type of tumor in a pig exists, but in dogs, tumor redevelopment at the site of anastomosis and development of distal metastases in previously unaffected organs are reportedly common.\(^15\)

The tumor detected in pig 5 of the present report was classified as an undifferentiated carcinoma but had features consistent with an adenocarcinoma. Given its location, the tumor was most likely of colonic origin. Colorectal carcinomas, although among the most common human types of cancer in some parts of the world,\(^17\) are rarely identified in veterinary species. However, among domestic animal species, dogs are most commonly affected with this type of tumor, and it has been hypothesized that this may be attributable to the fact that dogs share an environment that may expose them to the same carcinogens as humans.\(^17\) To our knowledge, no colorectal carcinomas in pigs have been
reported, but there is a report1 of a sow with a well- 
demarcated mucoid adenocarcinoma of the cecum that 
metastasized to a regional lymph node and lungs. In 
the pig of the present report, no evidence of metastasis 
was detected during surgery, and the mass was removed 
in its entirety by resecting a loop of the spiral colon. 
Subtotal colectomy and spiral-colon bypass procedures 
are described in Vietnamese potbellied pigs have been described,18,19 
but to our knowledge, this is the first that use of a 
side-to-side resection and anastomosis of the spiral co-
lon has been reported. The technique used was an 
adaptation of that described for removing the large colon 
in horses20 and allowed bypass of the affected loops of 
spiral colon without the need for extensive dissection of 
the mesentery.

Although neoplasia is generally considered rare in 
pigs, it should not be overlooked in the differential diag-
nosis of generalized abdominal distress in middle-aged 
and older Vietnamese potbellied pigs. As was evident 
in the pigs of this report, tumors can potentially arise 
from multiple components of the gastrointestinal and 
hepatobiliary tracts, including the liver, gall bladder, 
stomach, small intestine, and spiral colon. If neoplasia 
is suspected, tumor excision may provide a good out-
come. All 3 pigs that were treated surgically survived at 
least 9 months after surgery with good quality of life. 
Additional research is needed to determine the metas-
tasis rate of each type of tumor and survival rates for 
affected pigs, but our limited experience has indicated 
that early intervention can and should be attempted 
in these situations, with a reasonable expectation of a 
positive outcome.

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