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OBJECTIVE
To evaluate the reasons for and outcomes of gastrointestinal tract surgery in pet pigs.

DESIGN
Retrospective case series.

ANIMALS
11 pigs.

PROCEDURES
The medical record database of a teaching hospital was searched to identify pet pigs that underwent at least 1 celiotomy because of a possible gastrointestinal tract obstruction between 2004 and 2015. For each pig, information extracted from the medical record included history; signalment; clinical signs; physical examination, diagnostic imaging, and diagnostic test results; perioperative management; surgical diagnosis, duration, and procedures performed; postoperative complications; and outcome. Descriptive data were generated.

RESULTS
11 pet pigs underwent 12 celiotomies during the study period. Five pigs with intestinal obstructions caused by foreign bodies survived to hospital discharge. Four pigs were euthanized during surgery: 2 because of extensive adhesions that prevented correction of an intestinal obstruction, 1 because of a perforated spiral colon, and 1 because of neoplasia. One pig with a fecal impaction in the spiral colon died during anesthetic recovery. A diagnosis was not achieved for 1 pig, which was euthanized after surgery because of a deteriorating clinical condition. For the pig that underwent 2 celiotomies, the first procedure was an enterotomy for removal of a foreign body, and the second was an intestinal bypass of a stricture caused by adhesions at the previous enterotomy site.

CONCLUSIONS AND CLINICAL RELEVANCE
Results indicated prognosis was good for pet pigs following surgical removal of gastrointestinal foreign bodies; however, the presence or development of intra-abdominal adhesions appeared to adversely affect prognosis. (J Am Vet Med Assoc 2017;251:714–721)

The rise in the popularity of pigs, especially pot-bellied pigs, as pets is fairly recent.1,2 Pet pigs can develop GIT diseases that require surgical intervention (GIT surgical lesions). Pigs with GIT surgical lesions often have nondescript clinical signs such as lethargy, inappetence, vomiting, a decrease in fecal output, and abdominal distention.3,4 Intestinal obstruction can result from multiple causes including ingestion of foreign bodies, the development of intestinal adhesions subsequent to surgical procedures (eg, routine ovariohysterectomy), intussusception, or fecal impaction.3,4 Gastric ulcers, intestinal torsion or volvulus, and neoplasia can also cause GIT disorders in pigs.3,4 Some veterinarians may be uncomfortable diagnosing and treating diseases in pet pigs.5 However, techniques for the diagnosis of GIT disorders in pet pigs are the same as those commonly used in other species.3 Results of a thorough history, physical examination, radiography, ultrasonography, and other laboratory tests can be useful for determining whether pet pigs have GIT surgical lesions. Unfortunately, limited information is available regarding the diagnosis and surgical treatment of naturally occurring GIT disorders in pigs, but access to such information would be beneficial for the clinical evaluation of pet pigs with suspected GIT surgical lesions.

ABBREVIATIONS
AST Aspartate aminotransferase
bpm Beats per minute
CK Creatine kinase
GGT γ-Glutamyltransferase
GIT Gastrointestinal tract
SCMC Sodium carboxymethylcellulose
The objective of the study reported here was to determine the reasons for and outcomes of GIT surgery in pet pigs evaluated at a veterinary teaching hospital. Our primary hypothesis was that the prognosis for pigs with intestinal obstruction caused by a foreign body would be better than that for pigs with other, more insidious GIT surgical lesions. We also hypothesized that postoperative abdominal adhesions would be the primary cause of intestinal obstruction in pigs that required a second abdominal surgery.

Materials and Methods

Case selection criteria

The medical record database for the Virginia-Maryland College of Veterinary Medicine Veterinary Teaching Hospital was searched to identify pet pigs that were evaluated because of a possible GIT obstruction between 2004 and 2015. Pet pigs were defined as pigs that were kept as companion animals and not used for production purposes. Pigs that underwent at least 1 exploratory celiotomy for diagnosis or treatment of a GIT disorder were included in the study. Pigs that were managed medically or euthanized without surgery were excluded from the study.

Medical records review

For each pig included in the study, information extracted from the medical record included the history, signalment, duration of clinical signs prior to examination at the teaching hospital, physical examination findings, results of all diagnostic imaging and laboratory tests performed, and information regarding perioperative management, surgical diagnosis, surgical procedures performed, intraoperative use of SCMC, intraoperative complications, duration of surgery, postoperative management, postoperative complications, and short-term and long-term survival. For pigs that underwent multiple celiotomies, each surgery was considered as a separate surgical diagnosis and outcome.

A complication was defined as adhesion formation or death. Short-term survival was defined as patient survival to hospital discharge, and long-term survival was defined as patient survival for > 6 months following hospital discharge. Information regarding long-term survival was obtained from follow-up telephone conversations with patient owners.

Data analysis

Descriptive data were generated, and results were reported as the mean ± SD. The associations of perioperative duration of GIT disease, previous abdominal surgery, site of primary obstruction, cause of obstruction, procedure performed, intraoperative complications, and postoperative complications with survival were subjectively evaluated.

Results

Pigs

Ninety-two pet pigs were evaluated during the study period, of which 16 had a GIT disorder. Five pigs were excluded from the study because they did not undergo surgery. Thus, 11 pigs were included in the study; 10 underwent 1 surgical procedure, and 1 underwent 2 surgical procedures. Five pigs survived and were discharged from the hospital, 4 were euthanized during surgery, and 2 died or were euthanized during the immediate postoperative period.

The 11 pigs consisted of 6 castrated males with a mean ± SD age of 48 ± 36 months (range, 12 to 114 months), 3 spayed females with a mean ± SD age of 11.3 ± 9.0 months (range, 5 to 24 months), and 2 sexually intact females that were 18 and 24 months old. The overall mean ± SD age was 32.5 ± 31.9 months (range, 5 to 114 months) for all 11 pigs. The study population included 7 Vietnamese potbellied pigs, 1 Miniature pig, 1 Kunekune, 1 Yorkshire, and 1 mixed-breed pig. Mean ± SD body weight was 56.5 ± 97.0 kg (124.3 ± 213.4 lb; range, 4 to 360 kg [8.8 to 792 lb]) for all pigs; 1 pig weighed 4 kg, 3 pigs weighed between 10 and 20 kg (22 and 44 lb; mean ± SD body weight, 16.1 ± 0.17 kg [35.4 ± 0.37 lb]), 4 pigs weighed between 21 and 30 kg (46.2 and 66 lb; mean ± SD body weight, 26.1 ± 2.7 kg [57.4 ± 5.9 lb]), 2 pigs weighed 52 kg (114.4 lb), and 1 pig weighed 360 kg. Of the 11 pigs, 3 were housed outdoors exclusively, 3 were housed indoors exclusively, 3 had indoor and outdoor access, and 1 was kept in a stall. The housing was unknown for the remaining pig. Two pigs had undergone a surgical spay procedure 7 and 9 days prior to hospitalization for the GIT disorder.

Clinical signs

Clinical signs reported for the pigs immediately prior to examination at the teaching hospital included anorexia (n = 9), vomiting (8), a decrease in fecal production (6), and lethargy (5); some pigs had multiple clinical signs. The overall mean ± SD duration of clinical signs prior to evaluation was 41.4 ± 102.7 days (range, 0 to 365 days). The duration of clinical signs was < 1 day for 1 pig, 1 to 7 days for 6 pigs, 8 to 14 days for 1 pig, 21 to 28 days for 2 pigs, and > 365 days for 1 pig.

Physical examination findings

During the initial physical examination at the teaching hospital, the rectal temperatures for all 11 pigs ranged from below the detection limit of the thermometer to 39.4°C (below detection limit to 103.0°F; reference range, 38° to 39°C [100.4° to 102.2°F]). One pig was hyperthermic (rectal temperature, 39.4°C [102.9°F]), and 7 were hypothermic (mean ± SD rectal temperature, 36.3°C ± 2.0°C [97.3° ± 3.6°F; range, below detection limit to 37.9°C [below detection limit to 100.2°F]). Four of the 11 pigs were tachycardic (mean ± SD heart rate, 97 ± 49.6 bpm; range, 100 to 234 bpm [reference range, 60 to 90 bpm]), and 9 were tachypneic (mean ± SD respiratory rate, 33.8 ± 10 breaths/min; range, 20 to 48 breaths/min [reference range, 10 to 20 breaths/min]). Abdominal palpation was performed for 5 pigs, and all 5 had abdominal distention and signs of discomfort during palpation.
Diagnostic test results

Of the 11 pigs, a CBC was performed for 10 and a serum biochemical analysis was performed for 9. Only the PCV and serum total protein concentration were determined for 1 pig. The CBC (Table 1) and serum biochemical (Table 2) results for the 5 pigs that were discharged from the hospital and the 6 pigs that were euthanized during surgery or that died or were euthanized during the immediate postoperative period were summarized. The study population was too small for statistical comparisons between pigs that did and did not survive to hospital discharge. However, clinically relevant hematologic and biochemical findings included an abnormally high Hct in 5 pigs (mean ± SD Hct, 54.6 ± 4%; range, 47.4% to 59.8% [reference range, 36% to 43%], leukopenia in 5 pigs (mean ± SD WBC count, 6,800 ± 2,000 WBCs/µL; range, 3,700 to 9,200 WBCs/µL [reference range, 11,000 to 22,000 WBCs/µL], an abnormally high number of band neutrophils (ie, left shift) in 3 pigs (mean ± SD band neutrophil count, 3,000 ± 1,100 band neutrophils/µL; range, 1,400 to 4,000 band neutrophils/µL [reference range, 0 to 800

### Table 1—Summary CBC results for 11 pet pigs with GIT disorders that underwent surgery at a veterinary teaching hospital between 2004 and 2015 and did (n = 5) or did not (n = 6) survive to hospital discharge.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reference range</th>
<th>Pigs that survived to discharge</th>
<th>Pigs that did not survive to discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No.  Mean ± SD</td>
<td>No.   Mean ± SD</td>
</tr>
<tr>
<td>Hct (%)</td>
<td>36–43</td>
<td>5     49.1 ± 9.4</td>
<td>6     39.0 ± 10.4</td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>9–13</td>
<td>4     16.3 ± 3.2</td>
<td>6     13.4 ± 3.4</td>
</tr>
<tr>
<td>RBCs (X 10^6 RBCs/µL)</td>
<td>5–7</td>
<td>4     7.6 ± 1.6</td>
<td>6     7.3 ± 1.8</td>
</tr>
<tr>
<td>Reticulocytes (%)</td>
<td>0–12</td>
<td>48.0 ± 0.3</td>
<td>6     10.0 ± 0.9</td>
</tr>
<tr>
<td>MCV (fL)</td>
<td>52–62</td>
<td>4     63.0 ± 3.2</td>
<td>6     53.4 ± 4.7</td>
</tr>
<tr>
<td>MCH (pg)</td>
<td>17–24</td>
<td>4     21.6 ± 1.1</td>
<td>6     18.5 ± 1.9</td>
</tr>
<tr>
<td>MCHC (g/dL)</td>
<td>29–34</td>
<td>4     34.3 ± 1.0</td>
<td>6     34.4 ± 0.8</td>
</tr>
<tr>
<td>Platelets (X 10^11 platelets/µL)</td>
<td>200–500</td>
<td>3     341.0 ± 139.4</td>
<td>5     515.0 ± 404.5</td>
</tr>
<tr>
<td>WBCs (X 10^9 WBCs/µL)</td>
<td>11–22</td>
<td>4     9.4 ± 2.0</td>
<td>6     13.2 ± 9.9</td>
</tr>
<tr>
<td>Neutrophils (X 10^9 cells/µL)</td>
<td>2–15</td>
<td>4     5.3 ± 3.3</td>
<td>6     9.7 ± 10.1</td>
</tr>
<tr>
<td>Band neutrophils (X 10^9 cells/µL)</td>
<td>0.0–0.8</td>
<td>4     1.5 ± 1.5</td>
<td>6     0.7 ± 1.3</td>
</tr>
<tr>
<td>Lymphocytes (X 10^9 cells/µL)</td>
<td>3.8–16.5</td>
<td>4     1.2 ± 0.4</td>
<td>6     2.3 ± 1.3</td>
</tr>
<tr>
<td>Monocytes (X 10^9 cells/µL)</td>
<td>0–1</td>
<td>4     1.0 ± 0.3</td>
<td>6     0.5 ± 0.7</td>
</tr>
<tr>
<td>Eosinophils (X 10^9 cells/µL)</td>
<td>0–1.5</td>
<td>4     0 ± 0</td>
<td>6     0 ± 0</td>
</tr>
<tr>
<td>Basophils (X 10^9 cells/µL)</td>
<td>0.0–0.5</td>
<td>4     0 ± 0</td>
<td>6     0 ± 0</td>
</tr>
</tbody>
</table>

A CBC was performed for 10 of the 11 pigs; only the PCV (which was included in this table as a proxy for Hct) and serum total protein concentration were determined for the remaining pig. The values for some variables were unavailable for some pigs; therefore, the number of pigs that contributed to the mean calculation varies among variables. Of the 6 pigs that did not survive to hospital discharge, 4 were euthanized during surgery and 2 died or were euthanized during the immediate postoperative period. MCH = Mean corpuscular hemoglobin. MCHC = Mean corpuscular hemoglobin concentration. MCV = Mean corpuscular volume.

### Table 2—Summary serum biochemical results for the pigs of Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reference range</th>
<th>Pigs that survived to discharge</th>
<th>Pigs that did not survive to discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No.  Mean ± SD</td>
<td>No.   Mean ± SD</td>
</tr>
<tr>
<td>Fibrinogen (g/L)</td>
<td>200–400</td>
<td>4     450 ± 165.8</td>
<td>6     266.7 ± 47.1</td>
</tr>
<tr>
<td>AST (U/L)</td>
<td>15–55</td>
<td>3     80.7 ± 42.3</td>
<td>6     267.7 ± 499.4</td>
</tr>
<tr>
<td>CK (U/L)</td>
<td>66–489</td>
<td>3     1,167.7 ± 1,660.0</td>
<td>6     45,180.0 ± 97,432.5</td>
</tr>
<tr>
<td>GGT (U/L)</td>
<td>31–52</td>
<td>3     113.0 ± 43.5</td>
<td>6     44.8 ± 24.9</td>
</tr>
<tr>
<td>Bilirubin (mg/dL)</td>
<td>0.0–0.5</td>
<td>4     0.2 ± 0.1</td>
<td>6     0.4 ± 0.5</td>
</tr>
<tr>
<td>Calcium (mg/dL)</td>
<td>9.3–11.3</td>
<td>4     10.0 ± 1.2</td>
<td>6     9.6 ± 0.7</td>
</tr>
<tr>
<td>Chloride (mEq/L)</td>
<td>97–106</td>
<td>3     91.7 ± 4.1</td>
<td>6     94.5 ± 4.9</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>0.8–2.3</td>
<td>3     1.6 ± 0.1</td>
<td>6     2.2 ± 3.2</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>66–116</td>
<td>3     128.3 ± 15.2</td>
<td>6     111.8 ± 12.3</td>
</tr>
<tr>
<td>Magnesium (mg/dL)</td>
<td>2.3–3.5</td>
<td>3     2.3 ± 0.4</td>
<td>6     2.0 ± 0.5</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>5.5–9.3</td>
<td>3     6.7 ± 1.4</td>
<td>6     6.75 ± 1.9</td>
</tr>
<tr>
<td>Potassium (mEq/L)</td>
<td>4.4–6.5</td>
<td>3     3.9 ± 0.9</td>
<td>6     4.3 ± 0.9</td>
</tr>
<tr>
<td>Total protein (g/dL)</td>
<td>5.8–8.3</td>
<td>4     7.0 ± 1.4</td>
<td>6     6.0 ± 0.8</td>
</tr>
<tr>
<td>Albumin (g/dL)</td>
<td>2.3–4.0</td>
<td>3     3.8 ± 0.5</td>
<td>6     3.2 ± 0.7</td>
</tr>
<tr>
<td>Globulin (g/dL)</td>
<td>3.9–6.0</td>
<td>3     2.6 ± 1.1</td>
<td>6     2.8 ± 0.6</td>
</tr>
<tr>
<td>Sodium (mEq/L)</td>
<td>139–153</td>
<td>3     140.7 ± 4.0</td>
<td>6     135.8 ± 3.5</td>
</tr>
<tr>
<td>SUN (mg/dL)</td>
<td>8.2–25</td>
<td>3     21.0 ± 5.9</td>
<td>6     19.8 ± 8.9</td>
</tr>
</tbody>
</table>

A serum biochemical analysis was performed for only 9 of 11 pigs. See Table 1 for remainder of key.
band neutrophils/µL), lymphopenia in 9 pigs (mean ± SD lymphocyte count, 1,600 ± 800 lymphocytes/µL; range, 500 to 3,400 lymphocytes/µL [reference range, 0 to 800 lymphocytes/µL]), abnormally high serum AST activity in 5 pigs (mean ± SD, 355.8 ± 518.3 U/L; range, 58 to 1,391 U/L [reference range, 15 to 55 U/L]), abnormally high CK activity in 7 pigs (mean ± SD, 39,972 ± 91,071 U/L; range, 772 to 263,002 U/L [reference range, 66 to 489 U/L]), abnormally high GGT activity in 3 pigs (mean ± SD, 126 ± 25.3 U/L; range, 91 to 150 U/L [reference range, 31 to 52 U/L]), and hypoglobulinemia in 9 pigs (mean ± SD globulin concentration, 2.7 ± 0.8 g/dL; range, 1.0 to 3.5 g/dL [reference range, 3.9 to 6.0 g/dL]).

Other diagnostic tests performed included abdominal radiography (n = 10 pigs), abdominal ultrasonography (8), abdominocentesis (3), and esophageal endoscopy or gastroscopy (2). Abdominal radiographs were evaluated by board-certified veterinary radiologists and contained evidence of distended intestines (n = 10 pigs; Figure 1) and possible foreign bodies in the GIT (3; Figure 2). Abdominal ultrasonography revealed distended intestines (n = 8 pigs) and a possible foreign body in the GIT (1). Results of abdominocentesis and endoscopic procedures were unremarkable.

**Perioperative and surgical management**

Antimicrobials administered to the pigs during the perioperative period included ceftiofur sodium (n = 6 pigs), ceftiofur hydrochloride (2), ceftiofur crystalline-free acid (3), and trimethoprim-sulfamethoxazole (2); some pigs were administered more than 1 antimicrobial. Analgesics administered during the perioperative period included flunixin meglumine (n = 8 pigs), carprofen (5), buprenorphine (2), fentanyl (as a transdermal patch; 1), and meloxicam (1). Ten of the 11 pigs also received gastroprotectants while hospitalized; 4 received omeprazole, 4 received famotidine, 1 received omeprazole and cimetidine, and 1 received sucralfate and ranitidine.

The mean ± SD duration from hospitalization to surgery was 1.4 ± 2.0 days (range, 0 to 7 days). Four pigs underwent surgery the same day that they were initially examined at the teaching hospital, and 5, 1, and 1 pigs underwent surgery 1, 3, and 7 days after hospital admission, respectively. For the pig that underwent 2 celiotomies, the first procedure was performed 1 day after hospital admission and the second procedure was performed 4 days later (ie, 5 days after hospital admission).

Surgical diagnoses included simple intestinal obstruction (n = 8), adenocarcinoma (1), intestinal perforation (1), and undetermined (1). Intestinal obstructions were observed at various portions of the GIT, and some pigs with obstructive lesions had > 1 portion of the intestine affected and > 1 cause of obstruction. Causes of intestinal obstructions included fruit pits (n = 3 pigs), adhesions (3), fecal material (2), and linear foreign bodies (2). One pig had an adenocarcinoma that caused an intestinal obstruction. The obstruction was located in the jejunum (n = 6 pigs), spiral colon (3), transverse and descending colon (1),
and stomach and duodenum (1). One pig had a perforated spiral colon, and the abdomen was grossly contaminated with intestinal contents. One pig had extensive serosal adhesions that involved multiple GIT structures including the small intestine, spiral colon, and small colon. No GIT lesions could be identified during surgery for 1 pig.

A ventral midline approach was used for all 12 celiotomies. Surgical procedures performed included exploration only (n = 4), gastroscopy and duodenal enterotomy for removal of a linear foreign body (1), spiral colon enterotomy for removal of fruit pits (1), jejunal enterotomy for removal of fruit pits (2), jejunal enterotomy for visualization of an intramural mass (1), jejunal resection and anastomosis (1), and intraluminal infusion of sterile saline (0.9% NaCl) solution and gentle massage of the spiral colon or small colon to manually break down impacted fecal material (2). Five pigs had SCMC infused intra-abdominally prior to celiotomy closure.

For the pig that underwent 2 celiotomies, the initial procedure was a jejunal enterotomy for removal of a fruit pit. Four days later, the pig was lethargic, anorexic, and vomiting. Abdominal radiographs were obtained and revealed evidence of intestinal distention. A second celiotomy was performed, and multiple fibrous adhesions were found between portions of the jejunum, jejunum and body wall, and jejunum and mesentery as well as surrounding the previous enterotomy site, resulting in a jejunal stricture. Adhesiolysis and a jejunojejunostomy bypass were performed to direct ingesta around the stricture.

Intraoperative complications were encountered during 5 of the 12 celiotomies and involved the 3 pigs that had undergone previous abdominal surgeries, which resulted in intestinal adhesions; 1 pig with a spiral colon perforation; and 1 pig with an adenocarcinoma in the jejunum and abnormal nodules on the serosal surface of other portions of the GIT. Two of the 3 pigs with adhesions, the pig with the perforated spiral colon, and the pig with adenocarcinoma were euthanized during surgery because the lesion could not be corrected or because of a poor prognosis.

The mean ± SD surgical duration was 104.6 ± 36.4 minutes (range, 30 to 145 minutes) for all 12 surgeries and 76.3 ± 39 minutes (range, 30 to 130 minutes) for the 4 surgeries that ended with euthanasia of the patient.

Postoperative complications included spontaneous death during anesthetic recovery (n = 1 pig), development of intra-abdominal adhesions that necessitated a second surgery (1), and a decline in clinical condition resulting in euthanasia (1).

Outcome

Of the 11 pigs, 4 were euthanized during surgery, 1 died during anesthetic recovery, 1 was euthanized during the postoperative period, and 5 survived to be discharged from the hospital. The pig that died during anesthetic recovery had a spiral colon obstruction caused by fecal material, which was corrected by intraluminal infusion of saline solution and manual manipulation. It developed respiratory distress and died spontaneously during anesthetic recovery. The pig that was euthanized during the postoperative period had no GIT abnormalities identified during surgery. It had a 21-day history of abnormally decreased fecal production and acute pelvic limb paresis. Preoperative hematologic abnormalities included severe thrombocytopenia and leukopenia and the presence of metamyelocytes and toxic neutrophils. Histologic evaluation of biopsy specimens obtained from the spiral colon and cecum during surgery revealed evidence of acute, mild, suppurative colitis and typhlitis with intraluminal bacteria. The pig's clinical condition continued to deteriorate after surgery, and postoperative hematologic results suggested a grave prognosis, so the owners chose to euthanize the animal. The 5 pigs that survived to be discharged from the hospital included 2 pigs with linear foreign bodies, 2 pigs with foreign bodies (fruit pits) or fecal impaction, and the pig that underwent 2 celiotomies. Information regarding long-term (> 6 months after hospital discharge) survival was available for 3 of those 5 pigs. The owners of all 3 pigs reported no complications following hospital discharge and were very satisfied with the surgical outcome. The complete signalment, history, clinical and surgical findings, and outcome for individual pigs are available elsewhere (Supplementary Table S1, available at: avmajournals.avma.org/doi/suppl/10.2460/javma.251.6.714).

Discussion

Some veterinarians may be uncomfortable examining and treating pet pigs because of a lack of experience with such animals; however, the approach for diagnosis and treatment of medical disorders in pet pigs is similar to that used for dogs. Like dogs, pet pigs are prone to dietary indiscretion, which can result in the ingestion of foreign bodies that cause intestinal obstruction. The clinical signs associated with intestinal obstruction in pigs are similar to those in dogs and include anorexia, lethargy, vomiting, and abnormally decreased fecal production. For such patients, results of a thorough physical examination, diagnostic imaging, and laboratory tests will help determine whether exploratory celiotomy is warranted.

The most frequent clinical signs recorded for the pet pigs evaluated in the present study were vomiting and anorexia followed by a decrease in fecal production and lethargy. Pigs with intestinal obstructions caused by foreign bodies or adhesions had clinical signs for several hours to up to 1 week prior to being examined at the teaching hospital, whereas the duration of clinical signs for pigs with more insidious GIT lesions ranged from 14 days to 1 year prior to examination at the teaching hospital. Although physical examination findings varied among the 11 study pigs, all 5 pigs that underwent abdominal palpation had abdominal distention and signs of pain during palpation. Diagnostic imaging was beneficial for the evaluation of pigs with GIT disorders. Evaluation of abdominal radiographs revealed evidence of abnormal intestinal distention in all 10 pigs that underwent ab-
dominal radiography. Intestinal foreign bodies were detected by radiography in 3 pigs, and that diagnosis was subsequently confirmed during surgery. All 8 pigs that underwent abdominal ultrasonography had evidence of intestinal distention, but ultrasonography was less effective than radiography for identification of foreign bodies.

Results of another study indicate that hematologic and serum biochemical results do not vary significantly among pigs of traditional production breeds (production pigs), potbellied pigs, and Miniature pigs. Therefore, reference ranges established for production pigs were used to evaluate the hematologic and serum biochemical results for all pigs in the present study, regardless of their breed. Of the 11 pigs evaluated in this study, 5 had an abnormally high Hct, likely because of dehydration, and 9 had lymphopenia. Lymphopenia can be caused by acute inflammation or stress, and the pigs of this study were likely affected by both of those factors. Three pigs had a WBC differential count with a left shift (ie, a neutrophil count within or decreased from the reference range in conjunction with an abnormally increased band neutrophil count), which may have indicated that the bone marrow of those pigs was not adequately responding to an inflammatory insult because not enough time had passed to allow for an increase in granulopoiesis or there was excessive neutrophil damage and consumption. Granulopoiesis can take up to 5 days to become evident. The duration of clinical signs prior to hematologic evaluation for the 3 pigs with a left shift ranged from 6 hours to 4 days; thus, there may have been insufficient time for granulopoiesis to become evident in those pigs. However, pigs with GIT disorders generally have WBC abnormalities caused by an inflammatory response within the GIT.

Seven of the 9 pigs that underwent a serum biochemical analysis had abnormally high CK activity. Creatine kinase activity increases in animals with skeletal muscle disease, and the increase in CK activity for those 7 pigs was likely the result of lethargy, which led to prolonged periods of recumbency. Five pigs had abnormally high AST activity, which can result from muscle, liver, and (rarely) intestinal damage. The increase in AST activity observed for those 5 pigs was likely caused by muscle damage subsequent to prolonged periods of recumbency or liver damage subsequent to compression caused by GIT distention. Three pigs had abnormally high GGT activity, which may have been the result of compression of the liver and bile duct by the GIT lesion, as frequently occurs in horses with certain types of colic. Results of a study involving horses that underwent colic surgery indicate that there is a positive correlation among GGT, AST, and CK activities at the time of initial evaluation. In the present study, all 9 pigs for which serum biochemical analyses were performed had hypoglobulinemia, which was surprising given that serum globulin concentrations typically increase in response to inflammation owing to an increase in the synthesis of positive acute-phase proteins. A limitation of this study was that hematologic and serum biochemical analyses were not repeated for most of the pigs, and further investigation is warranted to determine how those indices change following correction of GIT surgical lesions.

The antimicrobials and analgesics administered to the pigs of the present study were selected on the basis of the preferences of the attending clinicians. Pigs that underwent IV catheter placement typically received drugs that could be administered by the IV route. Oral administration of drugs was generally avoided prior to surgery because of compromised GIT function. Following surgery and catheter removal, pigs were generally administered drugs by the oral or IM route. Pigs that required drug administration at home were typically prescribed drugs that could be administered orally because that route of administration was easiest for owners.

Abdominal surgery results in inflammation of serosal and peritoneal surfaces, and peritoneal injury can cause the development of adhesions. As the peritoneum heals, a fibrin matrix is formed, which serves as a platform for mesothelial cell migration and reepithelialization. When injured or inflamed serosal or peritoneal surfaces come into contact, fibrinous strands form between them. The fibrinolytic system generally breaks down those fibrous strands. However, surgery decreases fibrinolytic activity, and persistent fibrinous matrix leads to adhesion formation. Adhesions can cause signs of abdominal pain and intestinal obstruction. In human medicine, postoperative adhesions develop in >90% of patients that undergo abdominal surgery and are the primary cause of postoperative intestinal obstruction. Adhesions begin to form 24 to 48 hours after surgery and are well formed within 5 to 7 days after surgery. In horses, postoperative adhesions are the second most common reason for repeated laparotomy. In pigs, postoperative adhesion formation is well described, and pigs are routinely used experimentally for investigating adhesion induction. In the present study, all 3 pigs that had undergone a previous celiotomy (spay procedure [n = 2] or abdominal exploratory [1]) developed adhesions that resulted in intestinal obstruction and necessitated a second surgery. Two of those pigs were euthanized during the second surgery because the adhesions were extensive and prevented correction of the intestinal obstruction. In the present study, SCMC was administered during 5 of the 12 surgical procedures evaluated. Intraperitoneal administration of SCMC aids in the prevention of adhesions in laboratory animals and horses. Sodium carboxymethylcellulose creates a hydrofloation effect that mechanically separates serosal and peritoneal surfaces. When SCMC is administered prior to handling of the intestine, it coats the intestine and provides lubrication, which decreases friction when the intestine is manipulated and reduces inflammation and fibrin formation.
For pigs undergoing exploratory celiotomies, we advocate IP administration of SCMC prior to manipulation of the intestine and immediately before closure of the abdominal wall to help reduce adhesion formation. However, administration of SCMC is considered extralabel drug use under AMDUCA and requires adherence to an extended withdrawal period. The Food Animal Residue Avoidance and Depletion Program recommends a meat withdrawal of 24 hours following IP administration of SCMC to pigs.

The majority (9/11) of pigs evaluated in the present study had some type of intestinal obstruction, and the most frequent causes of intestinal obstruction were fruit pits (n = 3) and linear foreign bodies (2). Pigs, regardless of breed or use (production or pet), are foraging animals and search for food by rooting.\(^2\),\(^5\),\(^24\) The 2 pigs that had linear foreign bodies had fibrous material that appeared to be carpet removed during surgery. Both of those pigs were housed indoors and had a history of tearing carpet. Pet pigs that are housed indoors and denied the ability to forage and root can develop behaviors that are destructive to their environment (eg, carpet tearing) and can lead to the ingestion of foreign bodies.\(^2\),\(^5\),\(^24\) Therefore, pet pigs kept indoors may benefit from access to a rooting box.\(^2\),\(^24\) A rooting box is a large wooden box that contains stones that are too large for the pig to accidentally ingest.\(^2\) The pig’s feed is scattered among the stones, which forces the pig to root among the stones to find its food.\(^2\),\(^24\) Pigs often forage through the stones of a rooting box even after all the food has been consumed, which keeps them occupied and may reduce destructive behavior and ingestion of foreign bodies.\(^2\) The owner of one of the pigs of the present study made a rooting box with which to feed the pig following its discharge from the hospital and reported that the pig actively searched the box for food throughout the day.

Neoplasia-induced intestinal obstruction has been described in pigs, and affected pigs have clinical signs similar to those of pigs with other types of intestinal obstruction (eg, anorexia, vomiting, and a decrease in fecal production).\(^2\) In pigs, the prognosis for survival following surgical excision of a GIT tumor is generally good.\(^2\) Among the 11 pigs evaluated in the present study, only 1 had an intestinal obstruction caused by a neoplasm. That pig was euthanized during surgery because it had abnormal nodules on the serosal surface of the GIT at areas other than the site of obstruction (jejunum), which were suggestive of metastatic disease. Histologic evaluation of biopsy specimens subsequently revealed that the tumor was in fact malignant (adenocarcinoma).

Although the number of pigs evaluated in the present study was small and precluded formal statistical analyses, findings suggested that GIT foreign bodies were a frequent cause of intestinal obstruction in pet pigs and often required surgical correction. The prognosis for survival following surgical removal of foreign bodies appeared to be excellent for pigs in which postoperative intra-abdominal adhesions did not form. The risk for intestinal obstruction appeared to be increased for pigs that had undergone a previous celiotomy. For example, all 3 pigs that had intestinal obstructions caused by intra-abdominal adhesions had undergone a previous celiotomy, and 2 of those pigs were euthanized during the second surgery because the adhesions were so extensive that the obstruction could not be corrected. Thus, for the present study, the prognosis for pigs with a history of a previous celiotomy and the presence of intra-abdominal adhesions was poor. Additionally, the duration of clinical signs prior to examination and surgery appeared to be positively associated with the risk of death, probably because pigs with clinical signs of prolonged duration (ie, ≥14 days) had a more insidious disease process than a simple intestinal obstruction caused by a foreign body. In this study, neither the location of an intestinal foreign body nor the duration of surgery appeared to affect prognosis for survival.

Results of the present study suggested that pigs with clinical signs such as vomiting, lethargy, and inappetence should undergo a thorough physical examination, radiography, ultrasonography, and hematologic and serum biochemical analyses. Although pet pigs with GIT obstruction have varying clinical signs and medical management may be appropriate for some of those pigs, we recommend that any pig for which there is a high index of suspicion of a GIT obstruction undergo exploratory celiotomy as soon as possible. Proper surgical technique and IP administration of SCMC should reduce the risk of postoperative adhesion formation in pigs with GIT surgical lesions, which in turn should improve the prognosis for the long-term survival of those patients.

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**Footnotes**

a. Excel, Microsoft Corp, Redmond, Wash.

**References**

From this month’s AJVR

Evaluation of the effect of serum antibody abundance against bovine coronavirus on bovine coronavirus shedding and risk of respiratory tract disease in beef calves from birth through the first five weeks in a feedlot

Aspen M. Workman et al

OBJECTIVE
To evaluate the effect of serum antibody abundance against bovine coronavirus (BCV) on BCV shedding and risk of bovine respiratory disease (BRD) in beef calves from birth through the first 5 weeks in a feedlot.

ANIMALS
890 natural-service crossbred beef calves from 4 research herds.

PROCEDURES
Serial blood samples for measurement of serum anti-BCV antibody abundance by an ELISA and nasal swab specimens for detection of BCV and other viral and bacterial BRD pathogens by real-time PCR assay methods were collected from all calves or subsets of calves at predetermined times from birth through the first 5 weeks after feedlot entry. Test results were compared among herds, over time, and between calves that did and did not develop BRD. The associations of various herd and calf factors with test results were also evaluated.

RESULTS
At the calf level, serum anti-BCV antibody abundance was not associated with BCV shedding, but BCV shedding was positively associated with BRD incidence before and after weaning. The mean serum anti-BCV antibody abundance at weaning for a group of calves was inversely related with the subsequent incidence of BRD in that group; however, the serum anti-BCV antibody abundance at weaning for individual calves was not predictive of which calves would develop BRD after feedlot entry.

CONCLUSIONS AND CLINICAL RELEVANCE
Results indicated that serum anti-BCV antibody abundance as determined with ELISA was not associated with BCV shedding or risk of BRD in individual beef calves from birth through the first 5 weeks after feedlot entry. (Am J Vet Res 2017;78:1065–1076)