Clinical features, diagnostic methods, treatments, and outcomes associated with ingested wires in the abdomen of horses: 16 cases (2002–2013)

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OBJECTIVE
To describe clinical features, diagnostic methods, treatments, and outcomes associated with ingested wire foreign bodies in the abdomen of horses.

DESIGN
Retrospective case series.

ANIMALS
16 client-owned horses with ingested wire in their abdomens that were evaluated at a veterinary teaching hospital between April 2002 and February 2013.

PROCEDURES
Data for each case were collected from medical records and owners and then reviewed. Differences in clinicopathologic variables between horses that did (survivors) or did not (nonsurvivors) survive to discharge from the hospital were assessed.

RESULTS
The median duration of clinical signs prior to admission was 5.5 days (range, 0.5 to 1,095 days). Survivors (n = 4) had significantly lower median WBC count, neutrophil count, and plasma total protein concentration, compared with nonsurvivors (12), and all survivors underwent surgical treatment. Peritoneal fluid analysis revealed suppurative or septic peritonitis in all 8 horses tested. The presence of wire was confirmed by abdominal radiography (n = 6), exploratory laparotomy (2), and necropsy (8). The median length of ingested wire was 6 cm; wire had perforated viscera in 13 horses, 10 of which subsequently developed abdominal abscesses.

CONCLUSION AND CLINICAL RELEVANCE
Abdominal perforation by wire should be considered a differential diagnosis for horses with peritonitis and abdominal abscesses. Radiography is useful for detection of wire foreign bodies in the abdomens of horses. Given the guarded prognosis for affected horses suggested by results of the present study, early and aggressive treatment, including exploratory laparotomy to retrieve the wire and address perforations, peritonitis, and abscesses, should be considered. (J Am Vet Med Assoc 2018;253:781–787)

Materials and Methods

Case selection criteria
Medical records for horses admitted to the Colorado State University Veterinary Teaching Hospital between April 1, 2002, and February 28, 2013, because of colic or that underwent abdominal radiographic examination or exploratory laparotomy for colic during this time period were reviewed. Horses with a confirmed wire foreign body in the abdomen were included as cases in the study. Cases were categorized either as horses that were discharged alive from the hospital (survivors) or horses that were not discharged alive from the hospital (nonsurvivors). Horses without a confirmed wire foreign body in the abdomen were excluded from the study.

Medical records review
Data collected from the medical records of horses in the study population were history, signalment,
clinical signs, and physical examination findings on initial evaluation; results of hematologic and serum biochemical analyses, peritoneal fluid analysis, ultrasonography, and radiography; duration of hospitalization; treatment; findings from surgeries and necropsies; method of wire confirmation; wire foreign body characteristics and location; site of gastrointestinal perforation; and outcome (whether horses were or were not discharged alive from the hospital). Outcome data were further assessed on the basis of short-term survival (defined as survival to hospital discharge) and long-term survival (defined as survival > 1 year following hospital discharge, determined by telephone contact with horse owners).

Statistical analysis
Continuous variables were reported as median and range. A Mann-Whitney U test of medians was performed to identify differences in variables between horses that were or were not discharged alive from the hospital. All analyses were performed with standard software; values of \( P < 0.05 \) were considered significant.

Results
Animals
During the study period, 3,293 horses with colic or that underwent abdominal radiographic examination or exploratory laparotomy for colic were admitted to the Colorado State University Veterinary Teaching Hospital. Of those horses, 16 (0.5%) were identified as having confirmed wire foreign bodies in their abdomens. The affected horses included 6 mares, 8 geldings, and 2 stallions. Median age was 4 years (range, 1 to 34 years). Horses were recorded as American Quarter Horse (n = 5), Thoroughbred (3), American Paint Horse (2), Andalusian (1), American Miniature Horse (1), Clydesdale (1), Hanoverian (1), Missouri Fox Trotter (1), and mixed breed (1). The study population was divided into horses that were (survivors, n = 4) or were not (nonsurvivors, 12) discharged alive from the hospital. The nonsurvivor group included 11 horses that were euthanized and 1 horse that was dead on arrival.

Table 1—Clinicopathologic data obtained at the time of hospital admission from 15 horses with ingested wire foreign bodies in their abdomens that were (n = 4) or were not (11) discharged alive from the hospital.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reference range</th>
<th>Overall median (range)</th>
<th>Horses that were discharged alive from the hospital (n = 4)</th>
<th>Horses that were not discharged alive from the hospital (n = 11)*</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC count (X ( 10^3 ) cells/µL)</td>
<td>5.5–10.5</td>
<td>11.0 (1.5–22.3)</td>
<td>5.8 (3.9–7.6)</td>
<td>13.8 (1.5–22.3)</td>
<td>0.02</td>
</tr>
<tr>
<td>Neutrophil count (X ( 10^3 ) cells/µL)</td>
<td>3–7</td>
<td>8.0 (0.4–16.7)</td>
<td>4.3 (2.4–5.3)</td>
<td>10.3 (0.4–16.7)</td>
<td>0.02</td>
</tr>
<tr>
<td>Band neutrophil count (X ( 10^3 ) cells/µL)</td>
<td>0–0.1</td>
<td>0 (0–2.7)</td>
<td>0 (0–0)</td>
<td>0 (0–2.7)</td>
<td>0.53</td>
</tr>
<tr>
<td>Total protein (g/dL)</td>
<td>5.8–7.8</td>
<td>8.2 (4.4–9.6)</td>
<td>6.9 (6.3–8.0)</td>
<td>8.5 (4.4–9.6)</td>
<td>0.04</td>
</tr>
<tr>
<td>Globulin (g/dL)</td>
<td>2.9–5.0</td>
<td>5.7 (2.5–7.6)</td>
<td>3.8 (3.0–5.0)</td>
<td>6.0 (2.5–7.6)</td>
<td>0.07</td>
</tr>
<tr>
<td>Fibrinogen (mg/dL)</td>
<td>100–400</td>
<td>600 (200–1,100)</td>
<td>500 (200–800)</td>
<td>600 (200–1,100)</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Data are reported as median (range), and a Mann-Whitney U test was used to determine significant differences in variables between horses that were or were not discharged alive from the hospital. Values of \( P < 0.05 \) were considered significant. Concentrations of total protein, globulin, and fibrinogen were measured in plasma samples.

*A 12th horse in this group was dead on arrival at the hospital and not tested.

Clinical signs
The median duration of clinical signs prior to admission was 5.5 days (range, 0.5 to 1,095 days). Key findings on initial examination included signs of colic (10) and lethargy (8). Further, owners reported decreased appetite in 6 horses and that 1 horse had been fed from a tire with exposed wire. The median rectal temperature on initial examination was 37.8°C (100.0°F; range, 36.6° to 38.8°C [97.8 to 101.8°F]; n = 11), and the median heart rate was 48 beats/min (range, 30 to 90 beats/min). An abnormal abdominal mass was noted as being detected in 3 horses during rectal palpation. Median duration of illness prior to hospital admission did not differ significantly (\( P = 0.09 \)) between survivors (3 days; range, 0.5 to 5 days) and nonsurvivors (7 days; range, 0.5 to 1,095 days).

Clinicopathologic findings
Clinicopathologic findings at the time of hospital admission were available for 15 of the 16 (94%) horses (Table 1). The remaining horse was dead on arrival. Survivors significantly (\( P = 0.02, P = 0.02, \) and \( P = 0.04, \) respectively) lower median WBC count, neutrophil count, and plasma total protein concentration, compared with nonsurvivors. However, no significant (\( P = 0.53, P = 0.07, \) and \( P = 0.52, \) respectively) difference was detected between the 2 groups with regard to median band neutrophil count, plasma globulin concentration, or plasma fibrinogen concentration.

Results of peritoneal fluid analyses were available for 8 of the 16 horses (1 survivor and 7 nonsurvivors). For all assessed peritoneal fluid variables, median values exceeded upper reference limits. The nucleated cell count was 65.5 X \( 10^3 \) cells/µL (range, 4.1 X \( 10^3 \) cells/µL to 366.8 X \( 10^3 \) cells/µL; reference range, 5.0 X \( 10^3 \) cells/µL to 10.0 X \( 10^3 \) cells/µL), total protein concentration was 5.1 g/dL (range, 3.9 to 6.3 g/dL; reference range, 0.1 to 2.0 g/dL), and percentage of neutrophils observed was 83% (range, 78% to 94%; reference range, 40% to 80%). In addition, bacteria were observed during cytologic evaluation of peritoneal fluid samples from 3 of the 8 horses. Bacteriologic culture was performed on peritoneal fluid samples...
from 7 horses; 3 samples yielded bacterial growth, including a pure culture of *Escherichia coli* from 1 horse, a pure culture of *Actinobacillus* sp from a second horse, and a mixed growth of *Citrobacter freundii*, *E coli*, and *Enterococcus* sp from a third horse. On the basis of these findings, suppurative or septic peritonitis was diagnosed in all 8 horses for which peritoneal fluid samples were analyzed.

**Imaging**

Transcutaneous abdominal ultrasonography was performed on 15 horses in the study population but did not identify any metallic foreign bodies. In addition, transrectal ultrasonography was performed on 2 of the 3 horses in which abnormal masses had been detected during rectal palpation on initial evaluation. Of these 2 horses, 1 had a mass in its pelvic inlet, and, on the basis of echogenicity observed during ultrasonography, a metallic foreign body was suspected as a potential cause. This was subsequently confirmed by abdominal radiography. The other horse that underwent transrectal ultrasonography had an abdominal mass adjacent to its left paralumbar fossa; however, ultrasonographic findings were not suggestive of a potential cause of the mass. The third horse in which an abnormal abdominal mass was detected during rectal palpation did not undergo transrectal ultrasonography at the discretion of the attending clinician.

Abdominal radiography was performed for 7 of the 16 horses in the study population and revealed a single wire in 4 horses (Figure 1) and multiple wires in 2 horses (Figure 2). The detection of wire was an incidental radiographic finding in 2 horses that had been admitted for treatment of colonic impactions of feed or sand. The prevalence of ingested wires among horses that underwent abdominal radiography at the hospital was 4% (6/149).

**Treatment**

Treatments included the combination of surgery and medical treatment (n = 8), only medical treatment (6), and euthanasia without further treatment because of the severity of clinical signs (1). The remaining horse was dead on arrival at the hospital.

**Medical treatment alone**—Horses that underwent only medical treatment (n = 6) were administered IV balanced electrolyte fluids (60 to 90 mL/kg/d [27 to 41 mL/lb/d]) and flunixin meglumine (1.1 mg/kg [0.5 mg/lb], IV, q 12 h). Of the 2 horses that received antimicrobial treatment, 1 was administered ceftiofur crystalline-free acid (6.6 mg/kg [3.0 mg/lb], IM, once), and the other horse was administered penicillin G potassium (22,000 U/kg [10,000 U/lb], IV, q 6 h) in combination with gentamicin sulfate (6.6 mg/kg, IV, q 24 h). Horses that underwent only medical treatment were all euthanized < 36 hours after hospital admission because of progres-
sion of clinical signs (n = 5) or because a wire foreign body was confirmed by radiography (1).

Surgery combined with medical treatment—Exploratory laparotomy was performed on 8 of 16 horses in the study population. The median interval from hospital admittance to surgery was 7 hours (range, 1 to 100 hours). The decision to proceed with surgery was multifactorial and included whether horses had severe signs of gastrointestinal pain (n = 4), septic peritonitis (3), or confirmation of a wire foreign body on abdominal radiographs (3). Horses that underwent exploratory laparotomy were treated perioperatively with administration of IV balanced electrolyte fluids (60 to 90 mL/kg/d), flunixin meglumine (1.1 mg/kg, IV, q 12 h), and 1 of 4 different antimicrobial protocols: a combination of penicillin G potassium (22,000 U/kg, IV, q 6 h) with gentamicin sulfate (6.6 mg/kg, IV, q 24 h [n = 5]), a combination of penicillin G potassium (22,000 U/kg, IV, q 6 h) with enrofloxacin (5 mg/kg [2.3 mg/lb], IV, q 24 h [1]), penicillin G potassium (22,000 U/kg, IV, q 6 h) alone (1), or ceftiofur crystalline-free acid (6.6 mg/kg, IM, once [1]).

Four horses were euthanized during surgery because of extensive adhesions, abscess formation, or peritonitis and abdominal contamination secondary to intestinal perforation. Of the remaining horses (n = 4), wire was found to have perforated the small intestines (jejunum, 2; proximal aspect of the duodenum, 1) or to have been in a sand impaction of the large colon (1). In horses with a jejunal perforation, a jejunojejunostomy was performed after resecting the site of perforation and breaking down the surrounding adhesions (oment al ad hesions in one horse and splenic adhesions in the other). In the horse with a duodenal perforation, the wire and associated fibrinous adhesion were removed, and intraoperative abdominal lavage with crystalloid fluids through the surgical incision was performed; surgery was followed with daily abdominal lavage with balanced electrolyte isotonic crystalloid fluids through abdominal drains for 3 days. The horse with a large colon sand impaction containing a wire underwent pelvic flexure and right dorsal colon enterotomies; however, the wire was not identified despite targeted surgical exploration, and the horse recovered without wire retrieval (Figure 1).

All horses treated surgically and recovered from anesthesia were discharged alive from the hospital. The median duration of hospitalization for those horses was 9 days (range, 5 to 13 days), and the duration of antimicrobial treatment ranged from 5 to 12 days.

Necropsy findings

Necropsy was performed on 11 of the 12 non-survivors. The remaining horse was not necropsied because the owners elected to transport the horse back to the farm prior to euthanasia. One horse had a wire in an ingesta impaction of the large colon, but no evidence of peritonitis or intestinal penetration. In the remaining horses, wires were identified in fibrous masses or abscesses involving the gastrointestinal tract (n = 10), spleen (8), liver (2), diaphragm (1), and thorax (1). The horse with its thoracic cavity penetrated by a wire had septic pleuritis and pericarditis.

Confirmation, location, and characteristics of ingested wire

Diagnosis of ingested wire in the abdomens of horses (n = 16) was confirmed on the basis of radiographic examination results (6), exploratory laparotomy findings (2), or necropsy findings (8). Of the 16 horses, 14 had evidence of wire penetration of the gastrointestinal tract, and 11 had definitively identified sites of perforation including the jejunum (n = 3), left dorsal colon (3), right dorsal colon (2), small colon (2), and duodenum (1). Four of the horses with perforated colons had the site of perforation reported more specifically as in the diaphragmatic flexure (n = 3) and near the pelvic flexure (1). In 2 horses without a definitive perforation site, wire was found in an abscess adhered to the spleen (n = 1) and in an abscess adhered to the greater curvature of the stomach, spleen, dorsal and ventral colons, and midportion of the jejunum (1). With regard to the sites of perforation, a penetrating wire was identified in the cranial aspect of the abdomen in 11 horses. The median length of ingested wires was 6 cm (range, 4 to 15 cm).

Outcome

The median interval for follow-up with owners of survivors (n = 4) was 45 months (range, 12 to 48 months). All 4 horses in the survivor group were still alive at the time of follow-up. One of the horses had a colic episode 2 weeks after hospital discharge, but responded to medical treatment. All 4 horses had returned to the level of previous use, and the owners were satisfied with the health of their horses.

For the study population, the overall case fatality rate was 75% (12/16), and the case fatality rate for horses undergoing exploratory laparotomy for ingested wire was 50% (4/8). Comparatively, the fatality rate for all horses undergoing exploratory laparotomy at Colorado State University Veterinary Teaching Hospital for colic during the study period was 34% (258/755).

Discussion

To the authors’ knowledge, the present study was the first to describe clinical findings, diagnostic methods, and outcomes in a group of horses with ingested wire in their abdomens. Common sequelae to intestinal perforation by ingested wire were secondary peritonitis and abscess formation. The median total WBC count, neutrophil count, and total plasma
protein concentration for horses that were not discharged alive from the hospital (nonsurvivors) exceeded reference ranges and were higher than those for horses discharged alive from the hospital (survivors). The case fatality rate was high among horses in the present study, with surgical treatment an important factor for short-term survival (ie, alive at the time of discharge from the hospital). Furthermore, the long-term survival rate (ie, alive at > 1 year following hospital discharge) for those that survived to discharge was excellent.

Relative incidence of perforating wire foreign bodies in the lower alimentary tract of horses has been difficult to determine, in part because this disease process is rarely confirmed. For example, a perforating wire was detected in the abdomen of 1 of 555 horses necropsied at a referral hospital.9 In the present study, wire foreign bodies in the lower aspect of the alimentary tract were identified in only 16 horses over 11 years. This finding was similar to that of a previous study10 in which 12 horses with penetrating wire foreign bodies in abdominal abscesses were identified during a 15-year period, and somewhat higher than that of a study by Saulez et al,11 in which 4 horses with intestinal perforation by wire were identified during a 7-year period.

Recognition of wire foreign bodies as a source of peritonitis or abscess formation in horses is vital when deciding to pursue radiographic abdominal examination and instituting early surgical intervention. Exploratory laparotomy previously has been prompted by preoperative radiographic detection of a linear metallic foreign body (n = 1), colic combined with acute peritonitis (2), and signs of severe colic pain (2) in horses with ingested wire in their abdomens.11-13 Wire foreign bodies were not always found during surgery, even when the approximate location was known.1 In the present study, radiographic examination identified ingested wire foreign bodies in the abdomens of 6 of 7 horses. Abdominal radiographic examination has not been pursued commonly by attending veterinarians in many regions because radiopaque abdominal foreign bodies have not been encountered frequently in horses. Ingested wire foreign bodies in the abdomen are amenable to radiographic detection, in part, because of their predominant location in the cranial aspect of the abdomen; therefore, abdominal radiography could be considered more often for assessment of horses with fever, signs of colic, and evidence of acute peritonitis. Preoperative identification of linear metallic foreign bodies allows for more precise surgical planning and could increase the detection and successful removal of these inadvertently ingested materials, thereby improving prognosis.

Ingestion of foreign bodies can result in penetrating injury of the alimentary tract. The sites of injury caused by the foreign body and specific areas of the alimentary tract affected dictate the associated clinical signs. Penetration of the upper aspect of the alimentary tract is often associated with anorexia, ptyalism, dysphagia, and throatlatch or neck swelling, whereas penetration of the lower aspect of the alimentary tract is associated more typically with fever and colic signs.12,13,15-17

Several reports9,11-27 documenting metallic foreign body penetration of the upper and lower aspects of the alimentary tract elucidate, in part, the incidence of these conditions. Simhofer et al17 reported metallic foreign bodies in 4 horses admitted to a referral hospital; in 3 horses, the upper aspect of the alimentary tract was affected, and in 1 horse, the lower aspect of the alimentary tract was affected. Similarly, Schierz et al10 reported ingested wire perforation in 3 horses admitted to a referral hospital over a 1-year period; in 2 horses, the upper aspect of the alimentary tract was affected, and in 1 horse, the lower aspect of the alimentary tract was affected. Considering the previous reports and the results of the present study, ingested wire penetration of the intestines (eg, small intestine [n = 17] and colon [11]) appeared to be more likely than gastric penetration (4). However, in many cases, the specific site of penetration was unknown (8), but predominantly was suspected to have been in the cranial aspect of the abdomen.9,11-27 In the present study, 14 of the 16 horses had evidence of lower alimentary tract wire penetration and subsequent septic peritonitis.

Horses with subsequent wire penetration of the spleen and splenic abscess formation should be considered to have a grave prognosis given that all 5 similarly affected horses in the present study and 5 horses previously described14,21-23 died or were euthanized. Abscess formation is more likely to occur with chronicity, although predominantly fibrous tracts containing wire have been discovered without evidence of concurrent abscessation.11 When ingested wire goes undetected or untreated, the foreign body could perforate the alimentary tract and continue to migrate, exacerbating deleterious effects and potentially extending the duration of illness for 3 to 12 months after the original injury.12,14,21-23

Definitive treatment for a penetrating wire foreign body is surgical removal. For wire foreign bodies in the upper aspect of the alimentary tract, removal of the wire, drainage of associated fluids, and continued lavage are sufficient to result in resolution when paired with broad-spectrum antimicrobial treatment.4,5 Treatment of penetrating wire foreign bodies within the abdomen is complicated by peritonitis and formation of adhesions and abscesses.10-13,17 Intestinal resection is often necessary to successfully treat complicated visceral penetrations.10,11,20 Multiple bacterial isolates are often identified with penetrating injury of the alimentary tract.12 Abdominal lavage has been used following identification of peritonitis during exploratory laparotomy, and specifically in horses successfully treated for perforating abdominal wires.12,17 but was not performed on most of the horses of the present study. Despite this, surviving horses of the present study had excellent long-term outcome following surgical treatment. Survival time following
surgical treatment of ingested wires in the abdomen of horses has been reported to be 5 days, 20 11 days, 26,27 12 days, 17 6 months, 13 1 year, 22 and 3 years, 12 with equal numbers of horses euthanized at the time of surgery when the lesion was deemed inoperable. 11,14,23 A summary of case reports describing 26 horses treated for alimentary tract perforations from ingested wire revealed 10 horses that underwent surgical treatment and, of those, 5 horses survived to hospital discharge. 9,11-26

The case fatality rate of 75% (12/16 horses) in the present study implied a poor prognosis for horses with ingested wire in the abdomen and was higher than the reported mortality rate of 61% for secondary abdominal abscesses in horses. 10 Although prolonged antimicrobial treatment of horses with primary intra-abdominal abscesses from which a single bacterial pathogen was cultured has been reported, 29 horses with secondary intra-abdominal abscesses comprised of multiple bacterial pathogens do not have a favorable prognosis when treated long term with antimicrobials alone. 29 Although abdominal radiography has not been described as a useful diagnostic procedure for horses with intra-abdominal abscesses, 10,28-30 results of the present study suggested that radiography could be a useful diagnostic tool for detection of ingested wire in the abdomen of horses. Therefore, prior to initiating long-term antimicrobial treatments for horses with peritonitis or abdominal abscesses, abdominal radiography should be performed to help determine whether an ingested wire could be associated with the infection.

Transrectal ultrasonography contributed to the diagnosis of a wire foreign body in 1 horse of the present study, and metallic foreign bodies in the abdomens of horses have been detected previously with ultrasonography. 12 Transcutaneous abdominal ultrasonography was used in 15 of the 16 horses in the present study and is a sensitive diagnostic tool to detect splenomegaly, abdominal effusion, intestinal dilation, and soft tissue masses, which are often associated with ingested wire foreign bodies in the abdomen of horses. 11,13-15,18 Furthermore, ultrasonography is a useful investigative tool as an adjunct to radiographic examination or if radiography is not available when evaluating horses with peritonitis and abdominal abscesses for which an ingested wire foreign body in the abdomen is suspected.

As corroborated by the results of the present study, ingested wire foreign bodies in abdomens of horses can be incidental findings; however, ingested wire is often associated with visceral penetration, peritonitis, abdominal adhesions, abscess formation, and, rarely, thoracic penetration. Without prompt surgical intervention, the prognosis for horses with wire penetration of the lower aspect of the alimentary tract is poor. Additionally, findings of the present study supported the opinion that medical treatment alone is a poor treatment alternative because it will not resolve the underlying cause or associated signs. Failure to recognize the source of clinical signs and perform prompt removal of an ingested wire foreign body could result in continued migration of the wire, thereby extending disease duration and worsening prognosis. Further supporting prompt action is the potential for development of tetanus in association with wire penetration of gastric mucosa, as reported in a 4-year-old mare. 9 Even though many consider horses to be fastidious eaters, metallic foreign bodies in the alimentary tract of horses continue to be reported. 13 Care should be taken to limit exposure of horses to metallic foreign body sources (eg, tractor tire feeders, suture needles, hypodermic needles, and acupuncture needles) and wires within their feed and environment (eg, bedding) 9,6,14,18 and to initiate appropriate interventions promptly should inadvertent ingestion occur.

Acknowledgments

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Footnotes

a. Prism 6 for Mac OS X, version 6.0a, GraphPad Software, La Jolla, Calif.

References


### New Veterinary Biologic Products

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<thead>
<tr>
<th>Product name</th>
<th>Species and indications for use</th>
<th>Route of administration</th>
<th>Remarks</th>
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<tr>
<td><em>Escherichia Coli</em> Bacterial Extract (Epitopix, LLC, Willmar, Minn, US Vet Lic No. 365)</td>
<td>This product has been shown to be effective for vaccination of healthy cattle 5 months of age and older against <em>Escherichia coli</em> O157.</td>
<td>SC</td>
<td>USDA licensed 7/19/18</td>
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