Clostridiosis occurring in foals younger than 2 weeks of age usually manifests as acute, severe necrotic enteritis or enterocolitis. The causative agent is either Clostridium perfringens (usually toxin type A or C) or Clostridium difficile. Typically, affected animals are full-term and have received normal passive transfer from their dams. Clinical signs are often sudden in onset and include obtundation, inappetence, discolored mucous membranes, colic, abdominal enlargement, and bloody diarrhea. Radiography or ultrasonography may reveal peritoneal effusion and/or pneumatosis intestinalis. Treatment must be intensive and should include supportive care, antimicrobial therapy, and C. perfringens antitoxin. Despite treatment, most foals die. Because multiple cases may occur on the same premises, a preventive plan should be devised. This program may include immunization against C. perfringens, administration of preventive antimicrobials or probiotics, and changes in perinatal management practices.

Clostridiosis typically occurs in foals less than 2 weeks of age, clostridiosis is a sporadic cause of enterocolitis. Clostridiosis may be caused by Clostridium perfringens type A or C or Clostridium difficile. Typically, affected animals are full-term and have received normal passive transfer from their dams. Clinical signs are often sudden in onset and include obtundation, inappetence, discolored mucous membranes, colic, abdominal enlargement, and bloody diarrhea. Radiography or ultrasonography may reveal peritoneal effusion and/or pneumatosis intestinalis. Treatment must be intensive and should include supportive care, antimicrobial therapy, and C. perfringens antitoxin. Despite treatment, most foals die. Because multiple cases may occur on the same premises, a preventive plan should be devised. This program may include immunization against C. perfringens, administration of preventive antimicrobials or probiotics, and changes in perinatal management practices.

Clostridiosis typically occurs in full-term normal foals that have ingested adequate colostrum. Colic, abdominal enlargement, and bloody diarrhea are frequent clinical signs of clostridiosis. It is common for clostridiosis to recur on the premises in the same or subsequent season; therefore, a preventive program should be instituted immediately on diagnosis.

Data regarding the influence of nutritional status on relative risk of clostridiosis have been conflicting and difficult to interpret. Information extrapolated from other species suggests that feeding horses a high-energy diet (e.g., large amounts of alfalfa hay, grass, and grain) during the periparturient period increases milk production and thus can be a predisposing factor. The risk factors for neonatal clostridiosis caused by C. difficile are not well understood but likely include some of those discovered for C. perfringens. In the case of C. difficile, however, infective spores likely have come from other infected horses (or perhaps humans) rather than from livestock.

The actual cause of the disease can be any one of several potent clostridial exotoxins. These toxins disrupt the integrity of the wall of the small and/or large intestine, thereby allowing the transfer of toxic intestinal contents into the blood and peritoneal cavity and loss of water, electrolytes, plasma proteins, and blood cells into the intestinal lumen. Major toxins include α toxin of C. perfringens types A and C, β toxin of C. perfringens type C, and toxins A and B of C. difficile. Recently, it has been found that β1 toxin is produced by C. perfringens type A.
associated with necrotic enteritis in piglets; therefore, this toxin may play a key role in disease pathogenesis. Presence of \( \beta_2 \) toxin–producing *C. perfringens* has been associated with the occurrence of enterocolitis in adult horses; however, its role in neonatal clostridiosis has not been explored. *C. perfringens* enterotoxin is present in only a small proportion of isolates from horses (usually *C. perfringens* type A), and there is no evidence that it contributes to the virulence of the organism in foals. \( \beta \) toxin is trypsin sensitive and usually inactivated by digestive enzymes. It is believed that low amounts of digestive proteases in the neonatal gut and/or antiprotease activity in colostrum and milk may prevent inactivation of the toxin in some foals.

**Clinical Signs**

Clostridiosis typically occurs in full-term normal foals that have ingested adequate colostrum. Clinical signs begin from within 2 hours to 2 weeks after birth and range from sudden recumbency and death to mild diarrhea in an otherwise healthy foal. The mortality rate varies depending on the causative organism. The approximate median mortality rates of *C. perfringens* type C, *C. difficile*, and *C. perfringens* type A are 80%, 50%, and 25%, respectively.

The initial signs of clostridiosis are typical of those seen in foal sepsis (Figure 1A). There is obtundation and loss of interest in suckling. A common early sign is colic with increasingly prolonged and severe episodes of recumbency, rolling, and kicking at the abdomen. Initially, affected foals are febrile and have occasional high temperatures (104°F to 106°F). There is a reduction in intensity of auscultable gut sounds and progressive enlargement of the abdomen. Gastric fluid may reflux through or around an indwelling nasogastric tube. As the disease advances, septic shock occurs. Visible
mucous membranes become discolored and there is prolonged capillary refill time, increased skin tenting, entropion secondary to enophthalmos, weak pulses, cool extremities, and loss of the suckle reflex. Diarrhea, which may be profuse, fetid, and bloody, develops in foals that live for more than a few hours (Figure 1B). Even with treatment, affected foals often become laterally recumbent and moribund, and may die within hours of the onset of signs (Figure 2). Demented behavior and seizures may be seen in terminal foals.

Transcutaneous ultrasonographic examination of the abdomen often reveals thickened nonmotile, fluid-filled loops of intestine (small and/or large) with scant to abundant free peritoneal fluid. Occasionally, echogenic intramural patterns are suggestive of pneumatosis intestinalis. Lateral radiographs of the abdomen taken with the foal standing usually show loops of small and large intestine moderately distended with gas floating above the extensive fluid-dense ventral aspect of the abdomen.

**Laboratory Findings**

Complete blood count findings include normal to high fibrinogen concentration, leukopenia with a toxic left shift, high hematocrit, and normal or low plasma protein concentration.

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**TABLE ONE**

<table>
<thead>
<tr>
<th>Treatment Target</th>
<th>Agent</th>
<th>Dose</th>
<th>Route</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain control</td>
<td>Flunixin meglumine</td>
<td>1.1 mg/kg</td>
<td>IV</td>
<td>Twice daily</td>
</tr>
<tr>
<td>Pain control</td>
<td>Butorphanol</td>
<td>0.1 mg/kg</td>
<td>IV</td>
<td>Every 4 hr</td>
</tr>
<tr>
<td>Septic shock</td>
<td>Flunixin meglumine</td>
<td>1.1 mg/kg</td>
<td>IV</td>
<td>Twice daily</td>
</tr>
<tr>
<td>Septic shock</td>
<td>Normosol®-R® (or equivalent)</td>
<td>50 ml/kg</td>
<td>IV</td>
<td>First hour</td>
</tr>
<tr>
<td>Septic shock</td>
<td>Plasmalyte® 148/5% dextrose® (or equivalent)</td>
<td>10–20 ml/kg/day</td>
<td>IV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Septic shock</td>
<td>Sodium bicarbonate solution (5%)</td>
<td>0.5×BW×BE</td>
<td>IV</td>
<td>As needed</td>
</tr>
<tr>
<td>Septic shock</td>
<td>Plasma (2 L)</td>
<td>500 ml/hr</td>
<td>IV</td>
<td>4 hr total</td>
</tr>
<tr>
<td>Septic shock</td>
<td>Potassium penicillin G</td>
<td>44,000 U/kg</td>
<td>IV</td>
<td>Four times daily</td>
</tr>
<tr>
<td>Septic shock</td>
<td>Amikacin sulfate</td>
<td>22 mg/kg</td>
<td>IV</td>
<td>Once daily</td>
</tr>
<tr>
<td>Septic shock</td>
<td>Pressors</td>
<td>As needed</td>
<td>IV</td>
<td>As needed</td>
</tr>
<tr>
<td>Septic shock</td>
<td>(dobutamine, dopamine)</td>
<td>2–5 L/min</td>
<td>IN</td>
<td>As needed</td>
</tr>
<tr>
<td>Septic shock</td>
<td>Oxygen</td>
<td>2–5 L/min</td>
<td>IN</td>
<td>As needed</td>
</tr>
<tr>
<td>Clostridial infection and toxin production</td>
<td>Metronidazole®</td>
<td>10 mg/kg</td>
<td>IV</td>
<td>Four times daily</td>
</tr>
<tr>
<td>Clostridial infection and toxin production</td>
<td>Metronidazole</td>
<td>15 mg/kg</td>
<td>PO</td>
<td>Four times daily</td>
</tr>
<tr>
<td>Clostridial infection and toxin production</td>
<td><em>Clostridium perfringens</em> type C antitoxin (50 ml in 1 L fluids)</td>
<td>250 ml/hr</td>
<td>IV</td>
<td>4 hr total</td>
</tr>
<tr>
<td>Nutrition</td>
<td>Total parenteral nutrition</td>
<td>≥50 kcal/kg/day</td>
<td>IV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Nutrition</td>
<td>Enteral nutrition (milk)</td>
<td>50 ml/hr</td>
<td>NG</td>
<td>Every hour</td>
</tr>
<tr>
<td>Nutrition</td>
<td>Enteral nutrition (milk)</td>
<td>75–250 ml/kg/day</td>
<td>PO</td>
<td>As needed NG/suckle</td>
</tr>
</tbody>
</table>

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a Baxter Healthcare, Deerfield, IL.
b Abbott Laboratories, North Chicago, IL.
c Pressor agents should only be given after circulating volume has been restored.
d Metronidazole injection, 5 mg/ml, 500 mg. Switch to oral medications when the foal becomes tolerant to oral feeding.
e This information is according to published guidelines.

f Should be used concurrently with total parenteral nutrition to provide nutrients for enterocytes. Can be attempted only if there is no gastric reflux, abdominal distention, or signs of colic.
g To be increased gradually as the foal becomes tolerant to oral (or NG) feeding.

BE = base excess (mmol/L); BW = body weight; IV = intravenous; IN = intranasal; NG = nasogastric; PO = oral.
Prevention of Equine Neonatal Clostridiosis

Periparturient Management
- Reduce alfalfa and/or grain intake in periparturient mares.
- Move foalings to an area that can be easily cleaned.
- Use a sporicidal antiseptic (e.g., bleach) to clean area between foals.
- Keep foals at pasture after birth.

Immunization (*Clostridium perfringens* only)
- Vaccinate mares with type C (or types C and D) toxoid at 4 to 6 weeks and then again at 2 to 3 weeks before foaling.
- Prepare a custom-made vaccine for endemic *C. perfringens* type A problems.
- Administer 50 ml of anti-*C. perfringens* type C (or types C and D) antitoxin orally to foals before 6 hours of age.

Administration of Antibiotics and Probiotics
- Oral metronidazole (500 mg twice daily for 2 weeks).
- Lactic acid–producing bacteria (e.g., Probios\(^a\), 10 g at birth and then again at 4 days).
- *Saccharomyces boulardii* (e.g., Jarrow Formula,\(^b\) one capsule daily for 2 weeks).

\(^a\)Probios® equine oral gel, Chr. Hansen BioSystems, Milwaukee, WI.
\(^b\)JA Saccharomyces boulardii 100C; Web Vitamins; www.webvitamins.com.

*Intravascular hemolysis with hemoglobinemia and hemoglobinuria occurs in some foals. Serum IgG concentration is usually 800 mg/dl or higher. Abnormalities of serum chemistry values reflect multiorgan dysfunction and electrolyte and acid–base imbalances. There are high bilirubin and liver enzyme values, azotemia, a low total carbon dioxide concentration, hyponatremia, hypochloremia, and a high anion gap. Glucose concentration may be high initially but is often low during the terminal stages. Analysis of arterial blood gases typically shows severe acidemia caused by metabolic acidosis, which is sometimes complicated by respiratory acidosis, and hypoxemia. Peritoneal fluid samples may be classified as transudate to neutrophilic exudate. Foals with clostridiosis caused by *C. perfringens* type C or *C. difficile* are not bacteremic. In contrast, foals with C.*
*perfringens* type A may have positive blood cultures.

**Diagnosis**

Clostridiosis should be suspected in any foal with a history of normal colostral intake that show signs of rapidly progressive sepsis, especially when there is colic, bloody diarrhea, or a history of similar cases in the recent past on the same premises. A presumptive diagnosis is made by demonstration of abundant gram-positive bacteria in fecal fluid. The diagnosis is supported by culture of fecal clostridia on selective media (preferably with amplification by polymerase chain reaction of toxin genes) and detection of clostridial toxin in feces. Methods for diagnosis have been reviewed in the literature.4,6,7

**Treatment**

Neonatal clostridiosis is a medical emergency. Even with the best of care, many foals die; therefore, clients should be counseled appropriately. When there is a large volume of peritoneal exudate, the prognosis is grave and euthanasia is the best course. If attempted, treatment must be aggressive; therefore, an effective treatment plan must be established. Treatment should be aimed at the following problem areas: abdominal pain, septic shock, clostridial infection and toxin production, and maintenance of nutrition (Table One).

The suggested use of anti-*C. perfringens* type C antitoxin is off-label. The efficacy (if any) of this form of therapy is unknown. Although this type of antitoxin theoretically should contain antibodies against both α and β toxins (and thus be active against *C. perfringens* types A and C), it has been found that titers against α toxin are very low. Before administering an antitoxin, it is prudent to pretreat the foal with antihistamine (e.g., diphenhydramine, 1 mg/kg) then infuse the product slowly for the first 15 minutes while watching closely for signs of an infusion reaction. If the foal is able to tolerate enteral feeding, additional antitoxin may be given via that route. Hydroxyethyl starch solution may be given intravenously with or instead of plasma for intravascular volume expansion and, if blood loss into the intestine is severe, whole-blood transfusions can be given.

Even when treatment of the initial crisis is successful, subacute or long-term complications may occur. In my experience, these have included thrombosis of a major artery, intestinal obstruction because of adhesions between bowel loops, and failure to thrive.
Prevention

If a preventive program is not instituted immediately, it is common for clostridiosis to recur on the premises in the same or subsequent season (see Prevention of Equine Neonatal Clostridiosis). It should be noted that the use of *C. perfringens* toxoids is off-label. For the reasons stated above, toxoids elicit minimal anti–α toxin responses in vaccinated horses. Injection-site reactions have occurred after the use of oil-based toxoids (aluminum-adjuvanted toxoids apparently are better tolerated). The use of probiotics in this setting has not been thoroughly investigated. Probios® (Chr. Hansen BioSystems, Milwaukee, WI) and similar products are believed to work at least in part via production of lactic acid while *Saccharomyces boulardii* may compete with *C. difficile* toxin A for binding sites on intestinal epithelium.

References