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# ROTAVIRAL DIARRHEA

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Gastrointestinal disease is one of the most common afflictions of foals,<sup>4</sup> and outbreaks of infectious diarrhea cause considerable problems during the foaling season. It has only been within the past 15 years that viruses have been identified as the cause of foal diarrhea outbreaks.<sup>14</sup> Since then, intensive investigations have been undertaken to further define the possible causes of diarrhea, and rotavirus has been identified as the most common cause of foal enteritis in Central Kentucky, Ireland, and Great Britain.<sup>10, 19</sup> Rotavirus outbreaks most commonly occur in intensive horse breeding areas throughout the world.

Although the disease is highly contagious, few mortalities occur, which sometimes leads to the conclusion that the disease is not particularly significant. No study has outlined the actual cost of this disease to the horse industry; however, on one Standardbred farm, 54 foals valued at between 2 and 3 million dollars were sick at the same time.<sup>4</sup> In addition to the value of the animals at risk, the economic impact of this disease is significant in the cost of fluid and drug therapy, increased labor to manage sick foals, and precautionary measures of using protective clothing and disinfection to contain the outbreak. An effective equine rotavirus vaccine is not currently available, although other prophylactic measures have proven effective. This article discusses information on equine rotavirus and provides practitioners with practical techniques of prevention and control on breeding farms.

## VIRAL CHARACTERISTICS

The rotavirus particle, or virion, is composed of linear double-stranded RNA with an inner and/or outer protein coat (capsid); it is a nonenveloped virus. Rotaviruses are classified into groups A through G based upon common antigens within each group. Isolates from most domestic animals belong to Group A, including all known equine strains. Viral classification is reviewed in Figure 1.

There are at least six polypeptides in the virion: VP1, VP2, VP3, VP4, VP6,

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## Family Reoviridae

## Genus Rotavirus

Serogroups A–E (group members sharing a distinct common antigen); most rotavirus isolates belong to serogroup A, including all identified equine rotaviruses

Serogroup A has serotypes 1–14 (or G1–G14)

Identified equine rotaviruses primarily belong to serotype 3 (G3) (subtypes 1 and 2 have been identified)

**Figure 1.** Equine rotavirus classification. (*Data from references 6, 20, 32.*)

and VP7.<sup>34</sup> Serotyping is determined by the antigenic properties of the viral surface protein VP7. The Group A equine rotaviruses were originally classified into two serotypes, designated H-1 (serotype 5) and H-2 (serotype 3).<sup>23, 24</sup> By testing samples from foals naturally infected with rotavirus in central Kentucky, it was determined that serotype 3 is predominant; this has also been confirmed by studies on foals in Ireland and Britain.<sup>8</sup> Molecular studies have defined subgroups of serotype 3 rotaviruses.<sup>6, 7</sup> Two new rotavirus serotypes, 13 and 14, have been identified, but more research needs to be undertaken to determine the prevalence of these rotaviruses as well as isolates that are currently untypable.<sup>32</sup>

## TRANSMISSION AND PATHOPHYSIOLOGY

Since rotavirus was first recognized as a foal pathogen, the question of whether it is a primary etiologic agent or an opportunist has been debated. Infectivity trials have shown conclusively that rotavirus is a primary pathogen,<sup>14, 22</sup> and field investigators testing diarrheic foals for multiple viral, bacterial, and parasitic agents have come to the same conclusion.<sup>4, 10, 19</sup>

Serologic studies have shown that most adult horses have positive titers to rotavirus,<sup>14</sup> indicating exposure to the virus. During experimental infection<sup>22</sup> as well as in naturally occurring infections,<sup>17</sup> mares have shown four-fold increases in serum neutralization antibody, indicating that mares can become inapparently infected with the virus.

It has been demonstrated in other species that normal or subclinical adult animals shed rotavirus into the environment, but multiple fecal samples taken from mares during farm rotavirus outbreaks consistently tested negative.<sup>19</sup> This may be due to very low numbers of virus being shed at irregular intervals and the limitations of the testing methods used to detect the virus. It is theorized that adult animals may periodically shed rotavirus into the environment. Because the virus may persist in the environment for as long as 9 months,<sup>37</sup> a buildup of contamination occurs, especially when poor disinfection practices exist during the foaling season. Eventually, foals are exposed to a dose of virus that exceeds the level of protective local and systemic immunity, causing varying degrees of diarrhea. Also, many outbreaks have occurred after a mare and foal have shipped onto the farm and been immediately introduced into the resident herd without a period of quarantine. The foal, incubating the disease, breaks with diarrhea and begins an outbreak on the farm of immunologically naive foals. Rotaviruses are transmitted by the fecal–oral route, with foals ingesting feed or licking surfaces contaminated with the virus. During an incubation time of 18 to 24 hours, the virus infiltrates the epithelium of the villus tips of the duodenum and jejunum.<sup>14</sup> The loss of these functional absorptive cells results in maldigestion and malabsorption, causing diarrhea of varying severity. Because the intestinal crypt cells are not affected and continue to replicate to replace these absorptive cells, most

cases are self-limiting. Although the very contagious nature of the disease may cause high morbidity, with proper treatment, the disease has low mortality. Foals may become infected with the virus but be subclinical shedders during farm outbreaks, thereby further contaminating the environment with virus.<sup>19</sup>

## CLINICAL SIGNS

A variety of clinical signs have been reported by veterinarians and researchers dealing with foals that have rotaviral diarrhea. Animals from 2 days to 6 months of age may be affected with any of the following signs: watery to a pasty semi-solid diarrhea (nonhemorrhagic, ranging in color from bright yellow to greyish green), anorexia, depression, and dehydration.<sup>4, 19</sup> Diminished or absent nursing is often the first clinical sign noticed by farm personnel. Fever is not a consistent sign, and although there is a characteristic odor of rotaviral diarrhea, absence of this smell does not discount rotavirus as a diagnosis. Foals that recover shed the virus in feces for an average of 3 days after becoming clinically normal but usually do not experience recurrent rotavirus infections. Morbidity can be over 70% on breeding farms, but mortality is low: one study reported that of 196 sick foals, one 2-day-old foal died from rotavirus-associated diarrhea and dehydration, and one older foal developed rotavirus diarrhea and acute gastric ulceration symptoms and eventually was euthanatized after several months.<sup>19</sup> During a rotavirus outbreak that involved 82 of 164 Standardbred foals, none died from rotavirus diarrhea, although one foal did die from acute gastric perforation and peritonitis.<sup>4</sup> Foals younger than 2 weeks of age and those having symptoms of gastric ulcer disease are at higher risk of mortality. The cause-effect relationship of rotavirus infection and gastric ulceration remains unknown.

## DIAGNOSIS

Just as with *Salmonella* fecal cultures, one negative rotavirus test result should not be considered conclusive. From extensive field trials, rotavirus can be tentatively discounted as the etiologic agent only after 3 consecutive days of negative tests.

### Rapid Field Diagnosis

Because of a common capsid antigen, human rotavirus test kits can be used to diagnose equine rotavirus infections by antigen detection. Latex agglutination tests (Virogen Rotatest, Wampole Laboratories, Cranbury, NJ; MERITEC-Rotavirus, Meridian Diagnostics, Inc, Cincinnati, OH) can be used on the farm to obtain results in 15 minutes. Often, only small amounts of feces can be obtained from sick foals. Two rectal swabs obtained from foals can be used with these test kits as long as the sample is not overdiluted.<sup>16</sup> The Virogen Rotatest has shown 85% sensitivity and 95% specificity when compared with electron microscopy on equine fecal samples;<sup>19</sup> very similar results were obtained in a study of diagnostic kits of pediatric stool samples.<sup>35</sup> The tests are economic at \$6 to \$7 per fecal sample.

ELISA test kits are also available (Rotazyme II, Abbott Laboratories, North Chicago, IL); however, the procedure requires laboratory equipment and at least 3 to 4 hours to obtain test results. Studies of equine fecal samples using this kit

showed 89% sensitivity and 68% specificity;<sup>18</sup> tests on pediatric samples showed 92% sensitivity and 71% specificity.<sup>35</sup>

### Research Diagnostic Methods

Negative-stain electron microscopy (EM) is available only at a limited number of diagnostic laboratories and research facilities. It can be used to directly detect rotavirus or other viral particles. At least  $10^5$  virus particles/mL are required for detection by EM. If samples are to be sent to a diagnostic laboratory for EM testing, feces should be kept refrigerated, not frozen, because freezing may change morphologic characteristics of the virus.<sup>11</sup>

Other techniques that are currently used to detect rotaviruses are cell culture and polyacrylamide gel electrophoresis (PAGE). For electrophoresis, the virus RNA is extracted from the feces and run on a gel, where an electric field causes the virus genes to migrate in characteristic patterns. PAGE is the principal technique used for serotyping rotaviruses and is useful in epidemiologic studies.

### Serology

Even though serum neutralization (SN) tests have been developed for detection of rotavirus antibodies, experimental and field studies have shown that individual titers of mares or foals are not good indicators of resistance to disease<sup>22</sup> (Saif L, Ohio State University, August, 1992, personal communication). A four-fold increase in SN titers has been demonstrated in mares with rotavirus-positive foals, indicating exposure and possible subclinical infection, but this is not a consistent occurrence with mares during field outbreaks. Similarly, not all rotavirus antigen positive foals seroconvert. Therefore, practitioners should not rely on serology as a means of either diagnosing a rotavirus outbreak or determining a protective immune status of a mare or foal.

### DIFFERENTIAL DIAGNOSIS

A variety of known infectious agents cause foal diarrhea, including *Salmonella* spp, *Rhodococcus equi*, *Clostridium* spp, and various parasitic agents such as *Strongyloides westeri* and *Parascaris equorum*.<sup>5, 29</sup> When interpreting results from fecal cultures, the practitioner should be cautious in drawing conclusions. *Campylobacter* has been detected in both healthy and diarrheic foal feces and its role as a primary pathogen is not yet determined.<sup>19, 36</sup> Detection of the coccidian *Eimeria leukarti* in feces should be suspect for similar reasons.<sup>25, 26</sup> *Cryptosporidium* was once thought to only cause disease in immunodeficient foals, but it has been demonstrated that immunocompetent foals are susceptible to infection.<sup>13</sup> It can also be detected in the feces of subclinical foals.<sup>31</sup> Whether *Escherichia coli* can be considered significant on fecal culture remains under investigation.<sup>21</sup>

Both in equine studies<sup>10, 19</sup> as well as in human diagnostics,<sup>12</sup> only 50% of diarrheic cases were diagnosed as being caused by a specific etiologic agent. Other viral agents such as coronavirus, adenovirus, and parvovirus and bacterial agents like *Bacteroides fragilis*<sup>28</sup> and *Aeromonas hydrophila*<sup>10</sup> may be causes but, owing to diagnostic limitations, are difficult to detect on a routine basis. These considerations are important to emphasize to horse owners that have a possible contagious disease present on their farm. Precautionary actions should be taken

to limit the spread of cases of diarrhea before a definitive diagnosis is made, because laboratory tests may take 24 to 48 hours for results.

## TREATMENT

Perhaps the most important factor to consider in treating diarrheic foals is fluid and electrolyte deficits, especially in foals under 2 weeks of age, which can develop life-threatening dehydration within hours. If intravenous fluids are required, polyionic isotonic solutions can be used. Electrolyte levels should be monitored, because hypokalemia and acidosis may develop in severely affected foals, requiring careful fluid management.<sup>5, 27</sup>

Protectant/adsorbent products containing bismuth subsalicylate (Gastro-Cote, The Butler Co, Dublin, OH) given every 6 to 8 hours are commonly used and have proved to be effective. In geographic regions where gastric ulceration has been a problem in foals, antiulcer medication should be started as a prophylactic treatment.<sup>2</sup> The histamine-2 antagonists cimetidine and ranitidine have been used successfully to treat gastric ulcers in foals. One of these drugs is usually given along with sucralfate, which forms an ulcer-adherent "bandage" to protect the ulcerated area from further damage from hydrochloric acid, pepsin, and bile. To help reintroduce beneficial bacteria such as *Lactobacillus* into the gut, products such as Probiocin Brand Equine Oral Gel (Microbial Genetics, West Des Moines, IA) are often used and seem to help in some foals with enteritis. Plain, nonflavored yogurt with active cultures (30 to 60 mL orally, BID) also works well and is palatable, inexpensive, and readily available. Foals that develop high fevers should be judiciously treated with dipyrone or flunixin meglumine. Phenylbutazone and aspirin should be avoided, as they can cause gastric ulcers.<sup>1</sup>

Systemic and oral antibiotics should be avoided in routine cases of rotavirus enteritis; their use should be reserved for foals that have concurrent bacterial infections such as salmonellosis or other serious conditions that may predispose foals to secondary bacterial infections.

Nursing care is often neglected with diarrheic foals, but it is an important aspect in the animal's comfort and welfare. The tender skin under the tail and between the hind legs can scald and peel from encrusted diarrheic feces and urine. Hair can be lost from the tail and skin in improperly managed animals. To prevent this from occurring, mineral oil or petroleum jelly can be liberally applied to the tail and the skin between the hind legs to form a physical barrier to the scalding effects of feces. For foals that already have skin irritation, the skin and tail should be thoroughly and gently cleaned with a mild soap. Desitin Ointment (Leeming Division, Pfizer Inc, Parsippany, NJ), commonly used for diaper rash, is an effective treatment for scalded skin in foals. Besides providing a physical barrier to irritants, the zinc oxide relieves the burning, irritation, and inflammation of skin. This white ointment is difficult to remove from stall surfaces and the skin itself. The product V-Tergent 8X (Pitman-Moore, Inc, Mundelein, IL) is a detergent that easily liquefies and removes greasy substances and can be used to remove the ointment residue in the stall as well as on skin.

Finally, it should be emphasized to mare owners that the first 24 hours of life are critical for the foal to receive an adequate amount of quality colostrum. During this time, any oral medications should be given only under the advice of a veterinarian, because substances that would not ordinarily cross the intestinal barrier could be absorbed into the blood system, possibly causing adverse effects, including death. Oral products also may potentially interfere with the absorption of maternal antibody, compromising the foal's immune status.

## PREVENTION

Exposure to the virus alone does not cause a foal to get rotavirus enteritis, but rather, it is a result of combination of the immune status of the foal and the dose and virulence of virus ingested. Mares should be moved to the barn and stall where they will foal at least 30 days prior to their anticipated foaling date in order to expose them to resident antigens and provide subsequent antibody protection to their foals.

There is no way to guarantee that a foal will not be exposed to rotavirus in its environment; in fact, subclinical infections do occur in foals during farm outbreaks.<sup>19</sup> Why some rotavirus-positive foals are subclinical when a foal in the next stall of identical age becomes seriously ill with enteritis is unknown. What can be offered to horse owners are proven methods to limit the dose of virus the foal is exposed to by environmental control through disinfection, hygiene, and management techniques.

### Environmental Control

Rotaviruses are very stable in the environment, surviving at room temperature for up to 9 months.<sup>37</sup> Fecal suspensions of rotavirus can be frozen for three months at  $-70^{\circ}\text{F}$  ( $-20^{\circ}\text{C}$ ) and remain infectious. Once a rotavirus outbreak has occurred on a farm, there is no way to test or treat the pastures or paddocks to ensure that future foals will not be exposed. With this in mind, the feces collected from barns with positive foals should not be spread on pastures used by foals or weanlings to prevent their exposure to the virus.

To impress upon managers the importance of disinfection, hygiene, and management in preventing and controlling outbreaks of rotavirus, consider that there are  $10^9$  viral particles in 1 mL of diarrhetic feces. It has been shown that diarrhea can be induced in animals with no circulating rotavirus antibody with as few as 90 viral particles.<sup>30</sup> This means that 1 mL of diarrhetic feces can theoretically infect literally thousands of naive foals and explains why an outbreak can rapidly spread through a group of foals.

### Disinfection

Because rotaviruses are nonenveloped, they are resistant to many commonly used disinfectants. Studies have shown that phenolic disinfectants, specifically compounds with *o*-phenylphenol, *p*-tertiary amylphenol, and *o*-benzyl-*p*-chlorophenol have superior rotavirucidal activity. Bleach, chlorhexidine, and quaternary ammonium compounds are not effective.<sup>33</sup> Commercially available phenolic disinfectants commonly used on horse farms include Tek-Trol (Bio-Tek Industries, Atlanta, GA) and 1 Stroke Environ (Calgon Vestal Laboratories, St. Louis, MO). Stall surfaces need to be cleaned with a detergent to remove all organic matter. Both of the phenol products mentioned have detergents in the formulations and can be used in the initial cleaning step. Otherwise, an anionic detergent such as powdered Tide (Proctor & Gamble, Cincinnati, OH) should be used, because cationic and nonionic detergents are incompatible with phenolic compounds and should not be used. Disinfectants can be sprayed on the cleaned surfaces, allowed to dry, then reapplied. All foaling stalls should be disinfected prior to the foaling season and after each foaling. Individual disinfection pro-

grams should be established on farms prior to the foaling season according to the number of mares to foal, stall facilities, and available personnel.

## Hygiene

Rotavirus can survive drying and can easily be transferred from animal to animal by the hands and by inanimate objects.<sup>3</sup> When a foal breaks with diarrhea, it should be isolated from other animals, and every means should be taken to prevent the spread of the disease to other foals. Disposable gloves and boots should be used by personnel when handling and treating the animal. Equipment such as pitchforks and rakes should not be used in sick foals' stalls and then used throughout the barn: remember that only 1 mL of diarrheic feces is extremely infectious. Handwashing solutions effective against rotavirus, such as 10% povidone iodine, should be routinely used before and after working with sick foals and prior to handling young foals.

## Management

Once an outbreak of any contagious disease begins on a farm, all in-contact animals must be considered as exposed and potentially incubating the disease. A common mistake is to move normal but exposed foals away from the barn to other areas on the farm to get them away from the sick foal. This almost always ensures the spread of the disease throughout the farm. Sick foals can be isolated in the barn and personnel advised to be extremely careful to avoid all contact between those foals and other healthy ones.

Another management rule that should be rigidly enforced is that new animals to the farm should be isolated for a minimum of 7 days prior to being introduced to the resident population. Many outbreaks of rotavirus diarrhea as well as strangles, influenza, and herpesvirus abortion could be prevented by adhering to this one principle. This isolation period should also be used for animals that return from a veterinary hospital stay, because they are stressed and may have been exposed to infectious agents. More complete and detailed disinfection protocols and management techniques have been described.<sup>15,16</sup>

## Vaccination

Even though human rotavirus accounts for 5 to 10 million deaths annually worldwide,<sup>12</sup> researchers are still working at developing an effective vaccine. This underscores the difficulty of producing rotavirus prophylaxis and inducing the needed immunity at the intestinal level. Swine and bovine rotavirus vaccines are commercially available, and although anecdotal reports claim that use of the bovine vaccine in foals prevents diarrhea, no controlled studies have been attempted to substantiate this. No vaccine for horses is currently available commercially.

The most promising means of inducing immunity in foals include (1) vaccinating the mare prepartum to produce antibodies in colostrum, and (2) providing a hyperimmune colostrum product to boost local immunity at birth and/or at the time of an outbreak. Dosing foals orally with hyperimmune equine serum or bovine colostrum are also avenues that need to be researched for their potential effectiveness. Vaccination of foals younger than 3 months of age would likely be



blocked by any maternal antibody present. Studies are in progress to document the colostral transfer of rotavirus antibodies from mare to foal (Dwyer RM, Saif LJ, 1992). Initial prepartum vaccination trials of pony mares suggest that passive protection of foals against rotavirus is possible.<sup>9</sup>

## SUMMARY

Rotavirus poses a challenge each foaling season to farm managers and veterinarians in intensive horse breeding areas throughout the world. By understanding the epidemiology of the disease as well as characteristics of the virus, veterinarians can make sound recommendations on prevention and control of outbreaks. Even when effective prophylactic products are developed, farm management practices, including quarantine, disinfection, and hygiene, will always need to be in force to prevent any contagious disease outbreak.

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