

**Authors**

Linda J. Saif and Anastasia N. Vlasova,  
The Ohio State University, O.A.R.D.C., Wooster, Ohio

**Reviewer**

W.E. Morgan Morrow, North Carolina State University

## **Transmissible Gastroenteritis (TGE)**

---

### **Background**

Among the economically important diarrheal diseases of baby pigs, transmissible gastroenteritis (TGE) remains a cause of sickness and death. All age groups are susceptible. When the disease strikes a seronegative (antibody-free) herd at the time of farrowing, it is not unusual to lose most (often 100%) of the pigs farrowed under 3 weeks of age. A milder enzootic form of TGE, associated with chronic or intermittent episodes of diarrhea usually in 1- to 3-week-old suckling or recently weaned pigs, occurs in partially immune (seropositive) herds that have continuous farrowing or where pigs are regularly added or mixed. After a distinct respiratory variant of TGE (porcine respiratory coronavirus or PRCV) has spread throughout most parts of the world (first in Europe, and then in the US in the 1980's) occurrences of TGE have become more sporadic. Although accurate statistics are not available, the disease is still reported from parts of Europe, North America and Asia. Serologic surveys indicate that enzootic TGE is widespread throughout the US. Porcine respiratory coronavirus infections have complicated the diagnosis of TGE by generating cross-reactive antibodies that cannot be differentiated using conventional serologic tests, even though they are usually associated with only mild respiratory disease or sub-clinical infections.

### **Clinical Signs and Appearance**

Transmissible gastroenteritis is a mild disease except in pigs less than 3 weeks of age and in sows infected at or near farrowing. Pigs other than these have a more or less fluid diarrhea for 1 to a few days, vomiting may occur and the pigs usually go off feed for a short time. Because of reduced food intake pigs may lose weight, but in most cases they regain these losses. Clinical signs in newborn pigs are much more severe. Diarrhea starts 16 to 30 hours after the pig is exposed to virus. Thus, pigs born in a farrowing house in which a TGE outbreak occurs are born healthy and show the first signs of a TGE infection on the day following birth. Diarrhea observed in baby pigs during their first hours of life is not TGE. The first sign in baby pigs is almost always vomiting. This may be missed in pens where the sow runs free because she will eat the vomitus. Vomiting is followed very quickly by diarrhea. The first diarrhea, again, can be missed by a casual observer because it is very thin, watery, and will frequently run down the hind legs and drip from the tail. As the disease progresses, the diarrhea becomes more obvious because the skin of the rump is usually wet and soiled, and the odor of the feces becomes especially offensive. As the diarrhea thickens, it becomes yellowish, foamy, often containing small curds of undigested milk and is seen in little puddles on the floor. As the disease progresses, the pigs become dehydrated and have eyes that are sunken and a rough hair coat. They are very thirsty and will drink water or attempt to suckle even when weak. Most pigs that die of TGE do so 2 to 5 days after they become infected, but in some cases death may occur sooner. The younger the pigs are when infected, the shorter the interval from onset of diarrhea to death.

Pigs that have TGE are highly sensitive to chilling, and this may be a partial explanation for the rapid deaths sometimes seen. Pigs that live more than 6 to 8 days usually will recover. In most cases recovered pigs will do well, although in some herds, pigs may remain unthrifty. Sows infected just before or after farrowing become feverish and depressed, often vomit or refuse feed, and have a greenish diarrhea that persists for 1 to a few days. Feed refusal is the first and most common sign of sows sick with TGE. Their milk quantity diminishes, and they may even quit milking. In some cases, if the litter continues to suckle, they return to normal lactation.

Figure 1. Electron microscopy (EM) of negatively stained transmissible gastroenteritis virus particles. Arrow points to surface club-shaped projections or spikes that form the “corona” surrounding the particle. Porcine respiratory coronavirus particles have an identical morphology and cannot be distinguished by EM. x195,000.

Figure 2. Scanning electron micrograph of normal small intestine, showing villi that line the intestine. These projections increase the surface area and are covered with the cells that digest and absorb nutrients from the feed. x200.

Figure 3. Scanning electron micrograph of the small intestine, as it appears after infection with TGE virus. The surface cells are killed and shed, resulting in shortening of the villi and loss of the ability to digest and absorb nutrients. If the pig survives, villi will regain their original form in 1 week to 10 days. x200.

## The Cause

Transmissible gastroenteritis is caused by a coronavirus. This virus is characterized on the basis of its distinctive morphology as enveloped, rounded but variably-shaped particles surrounded by a “corona” of club-shaped spikes (Fig. 1). The virus is covered by an envelope that is destroyed by detergents and inactivated by warm temperatures, drying and sunlight. The virus is resistant to acid, allowing it to pass through the stomach and infect the small intestine. It survives for long periods in a cold, dark environment and almost indefinitely when frozen.

## How the Virus Causes Disease

Transmissible gastroenteritis virus (TGEV) has a special affinity for cells that line the small intestine. These cells cover millions of tiny villi that project into the intestine to provide a huge surface area that functions to digest and absorb nutrients from ingested food (Fig. 2). When TGEV enters these cells, it multiplies and destroys the cell within 4 to 5 hours. Once the cell dies, thousands of virus particles are released to infect other similar cells. After 4 to 5 cycles of virus multiplication, almost all of the digestive cells in the baby pig are killed, resulting in atrophy of intestinal villi most noticeable in the jejunum and ileum. As part of a healing response, immature cells in the small intestinal lining are quickly produced to provide a covering for the villi. However, these cells cannot effectively digest or absorb nutrients or water (Fig. 3). The destroyed cells are replaced with normal cells within 1 to 10 days if the pig survives. Milk or other foods that are ingested are not digested in TGEV infected pigs. Undigested nutrients, unabsorbed water, lost body fluids and electrolytes cause diarrhea. Loss of fluids and salts upsets the saltwater balance in the blood which then becomes acidic. The resulting dehydration, and failure to absorb nutrients, causes starvation. The pig dies of a combination of these factors and abnormal cardiac function due to electrolyte imbalance, although complications of stress, chilling and secondary infections may also be involved.

## Diagnosis

An accurate diagnosis is necessary to establish treatment and management of the infected herd. A presumptive diagnosis of TGE may be made on the basis of clinical signs. However because the porcine epidemic diarrhea coronavirus (PEDV) causes similar clinical signs and deaths in baby pigs, differential diagnosis is needed for the two enteric coronaviruses. The pattern of a rapidly spreading diarrheal disease involving breeding stock, feeder pigs and baby pigs is typical of both TGE and PED, but this scenario is not always seen. It may be different in the absence of baby pigs or when part of a herd is immune. In baby pigs, the small intestine will have very thin, translucent walls with congested mesenteric vessels. Postmortem finding of severe shortening of the villi of the small intestine (in the jejunum and, less commonly, in the ileum), as shown in Figure 3, perhaps with squamous metaplasia of epithelium, and elongation of crypts in scattered areas of the jejunum and ileum, is indicative of TGE, but various degrees of villous atrophy may occur in other diarrheal diseases of pigs, notably PEDV and rotaviral infections, so these lesions require careful interpretation. Also PEDV, but not TGEV, reportedly infects the colon. Watery colonic contents usually have an acid pH. A presumptive diagnosis can be made based on clinical signs in the newborn pigs, a histological evaluation to detect villous atrophy, and the FA test using specific TGEV antibodies to detect TGEV-infected cells in the small intestine and to differentiate the infection from PEDV. Although traditional serological assays [virus neutralization and fluorescent antibody (FA) staining] can

differentiate TGEV from PEDV infections, these assays are complicated by the fact that the TGEV antibodies induced after infection do not discriminate between TGEV and PRCV infections. Specific and sensitive detection of TGEV/PRCV nucleic acids can be done using reverse-transcriptase polymerase chain reactions (RT-PCR). Additionally, by using virus-specific primers, this test allows discrimination between TGEV and PRCV and between TGEV and PEDV. Unlike TGEV and PEDV, porcine respiratory coronavirus does not cause vomiting, diarrhea or villus atrophy in young animals and it replicates in the respiratory tract.

In some herds, an atypical pattern of TGE occurs in pigs whose mothers are partially immune as a result of previous exposure to the disease. In such herds, diarrhea occurs mainly in suckling pigs over 8 days of age or in recently weaned pigs. This form of TGE, commonly referred to as enzootic TGE, occurs mainly in herds on a frequent or continuous farrowing schedule. This presents a situation where susceptible pigs perpetuate the infection. An accurate diagnosis of enzootic TGE can be difficult and must be differentiated from diarrhea due to PEDV and rotavirus since they also occur mainly in pigs of this same age group, and coccidiosis (caused by *Isospora suis*), which mainly causes diarrhea in 7- to 10-day-old pigs.

## Immunity

One of the most effective and widely used methods of combating viral diseases is immunization, but in spite of considerable effort by federal researchers, universities and commercial industries, a completely safe and effective TGE vaccine is not available at this writing. Immunity to TGE and other diseases of the intestine is a complicated subject and still incompletely understood. The problem with immunity to TGE stated briefly is: the pigs must have immunity during the first days of life. A sow that has been infected naturally provides immunity to its pigs through her colostrum and milk (lactogenic immunity). Her pigs are immune as long as they suckle. If they stop suckling for any reason, they become susceptible within hours because their immunity depends upon the presence of milk antibody in the gut. Currently there are multiple federally licensed TGE vaccines available for use in pregnant sows to provide some protection for their suckling pigs. The vaccines are either killed virus or modified live virus products and usually are given about 6 weeks to 2 weeks before farrowing. Routes of vaccination include oral, intramuscular, intramammary or combinations of these routes. These vaccines provide only limited protection against infection and diarrhea, but in some circumstances they may tend to reduce death losses, especially in herds experiencing enzootic TGE. The practical solution is to develop a safe vaccine that will stimulate the same IgA type antibodies in sow's milk as a natural infection. Injected vaccines cause high levels of IgG type antibody to appear in colostrum (the first milk), but 1 to 3 days after farrowing, and thereafter, only low levels of IgG antibody occur in milk. Thus, the pigs of a sow given an injected vaccine may be transiently protected against TGE while suckling colostrum, but within a few days of birth they become susceptible as the colostrum is replaced by milk. It is possible to produce substantial immunity by planned infections of sows with the indigenous virulent TGE virus strain. By giving a single dose of homogenized small intestines from young pigs acutely infected with TGE to a sow at least 3 weeks before farrowing, she will be able to protect most of her suckling pigs against the virulent TGE virus. However the viability of the virus in the homogenates and the doses consumed may be variable for each sow resulting in uneven levels of immunity. Also this is a hazardous method of controlling the disease because the planned infection may not be contained. It may spread to other herds in the area, or start an enzootic TGE infection in the herd. Sows also could be infected with other pathogens from the donor pigs' intestines. Despite the hazards involved, there are certain situations in which the procedure can be justified and beneficial. Finally, some research indicates that multiple exposures of sows to PRCV resulted in high levels of TGEV IgA antibodies in milk and provided a high degree of protection to experimental TGEV challenge.

## Epidemiology

Epidemic TGE is observed most often in winter and occurs in herds where most of the pigs are TGEV/PRCV-seronegative. Morbidity is high in epidemic TGE and pigs under 2-3 weeks of age tend to show severe diarrhea and rapid dehydration, which often result in death. The overall herd mortality rate is usually less than 10-20%, but above 80% in baby pigs. A cost-effective means of controlling diseases of livestock is based on sanitation; that is, keeping the animals and pathogens separated and reducing pathogen load. Good sanitation procedures depend upon knowledge of the epidemiology of the disease in question. There are still many unanswered questions as to how TGE virus survives and spreads in nature or during the summer months. Transmissible gastroenteritis is a disease exclusively of swine. No reservoir of infection other than swine has been identified. However cats, dogs and foxes and cats (and other wild and domestic carnivores,

possibly including mink) can become infected with TGE virus and may shed the virus in their stools for up to 2 weeks. They could be involved in herd-to-herd spread of virus during an epidemic, but they are less likely to contribute to the survival of the virus from year to year. House flies have been proposed as possible vectors for TGE. Transmissible gastroenteritis virus was detected in flies associated with an enzootic herd and experimentally inoculated flies excreted TGE virus for 3 days. They too are unlikely to play a role in the survival of the virus from year to year. Massive flocks of starlings can be found in feedlots during the winter when TGE is most prevalent, and circumstantial evidence suggests that they may be involved in herd-to-herd spread of TGE during epidemics. Attempts to infect starlings with TGE virus have failed, although virus can survive in their intestines for at least 36 hours. Thus, starlings could eat feed contaminated with virus at one farm and shed the virus in their stools some time later at another farm. It is also possible that starlings carry virus from herd to herd on their feet or feathers. There is nothing, however to indicate that they function to keep TGE virus alive from one season to another. The most important animals involved in the maintenance and spread of TGE are swine and humans. Swine are the reservoir of the virus, and people, through their activities, help spread the virus from herd to herd. The natural route of infection of pigs with TGE virus is by ingestion, or in close quarters, by airborne virus as pigs may be infected by inhalation. Virus multiplies in the gut and when passed in the stools, other pigs become infected. The quantity of virus in the diarrheic stools is very high (up to a million infectious doses per gram) during the first days of the disease. It decreases as the pigs recover and the stool becomes solid. With one questionable exception, virus has not been found in the feces of pigs for more than 2 weeks after infection. Virus may persist in the gut and possibly the respiratory tract for as long as 2 or 3 months. Whether this virus is shed in high enough quantities to be infectious and start new infections is an unresolved question. TGE virus can persist for long periods under conditions in which new pigs are continuously added to a group. In large continuously farrowing herds, most of the sows may be immune and their pigs will be totally or partially protected while they are suckling the sows; however, the pigs will have no protection after weaning. As discussed under "Diagnosis," this pattern of enzootic TGE in a herd can be difficult to diagnose. Weaned pigs with TGE usually do not die as a result of the infection but they may provide a reservoir of the virus for other pigs in the same herd. In situations in which weaned pigs from different herds are commingled, they may also serve to maintain TGE virus; in fact TGE has been documented in pigs involved in medicated early weaning studies. The major means of spread of TGE virus among herds is feces from recently infected pigs. TGE virus can be carried among herds most effectively by movement of pigs, but also, by anything that is likely to be contaminated with manure and moving among herds. This includes equipment, feed, trucks, fomites and people. People may carry virus on their hands and clothing as well as on their shoes or boots. New TGE outbreaks usually occur in the winter. This can be explained at least partially by the fact that the climatic conditions of winter, that is, low solar radiation due to long nights and cloudiness, and low temperatures, favor the survival of the virus as it is carried among herds in pig stools. The conditions of intense solar radiation and high temperatures occurring in the summer reduce the chance for virus to be carried. Also of possible importance is the tendency for large numbers of starlings to feed close to swine in the winter months, especially after a snowfall.

## Treatment

As is the case with most viral diseases, no drugs are effective against TGE virus in swine, although interferon showed a moderating effect in one study. Lacking cheap and specific antiviral drugs, treatment must be directed at the effects of the virus rather than at the virus itself. As was indicated earlier, the cause of death in TGE is starvation, dehydration and acidosis. Injecting sick pigs intravenously or subcutaneously with electrolytes as has been done in the laboratory, is expensive, time consuming and impractical on the farm. Although affected pigs have a reduced ability to absorb water and nutrients, the provision of water and supplemental heat will help to offset dehydration and decrease the demand for energy by keeping pigs warm. Doing two things for TGEV-infected pigs, keeping fresh water before them at all times and providing a draft-free place with a temperature of 90°F, can significantly reduce losses especially in pigs that are 3 to 4 days or more of age at the time they are infected. Pigs infected during the first day of life do not cope as well and the disease is usually fatal. In some cases, secondary bacterial infections appear to be involved, and antibiotic treatment may be advisable though it will not affect the course of the viral infection in the pig.

## Management of TGEV-Infected Herds

Management is an effective and the least expensive means of reducing losses in a TGE-infected herd. It should be directed not only at saving pigs already infected, but also at preventing infection of pigs to be farrowed, and very importantly, preventing spread to other herds in the area. Because each herd differs in its facilities, farrowing schedule, marketing goals, availability of labor and other factors that influence management decisions, a veterinarian who understands in detail the pathogenesis, epidemiology and immunity to TGE (which were briefly outlined previously) can be most helpful. Some procedures to be considered follow. Pigs born to non-immune sows in a room in which other pigs have TGE are almost certain to break with TGE on the second day of life. Therefore, sows farrowing in the 10 days or 2 weeks after an outbreak starts should be moved to other quarters. This reduces the probability that their pigs will become infected, and shortens the time that the farrowing room will be contaminated. Individual houses with attached pens, separated from each other by a few feet, are ideal but not usually available on modern farms. It is usually possible, however, to find some accommodation for sows outside of the infected farrowing house. Even sows that farrow as early as the first night after removal from the contaminated farrowing house may have litters that remain healthy if care is taken to maintain their isolation. In herds with enzootic TGE, in addition to all-in/all-out system of production with cleaning and disinfection between farrowings, deliberate infection of pregnant sows with the virus already on the farm may be useful. This is best done by chopping or grinding the virus-containing intestines of newly infected pigs in water and by adding the slurry ideally to individual sow's feed to assure uniform doses and consumption. There is no evidence to suggest that live TGE virus administered to pregnant sows causes abortions or in utero infections. The infected sows develop some immunity in about 10 days and it becomes stronger during the next weeks. Such sows may then be moved into the farrowing house. The effectiveness of this procedure is increased if all sick pigs are removed and the room is thoroughly cleaned and allowed to stand at about 70° to 80°F for 2 or more days. Under some circumstances, it may be useful to deliberately expose growing swine as well as sows. This may shorten the total time the disease is active on the farm over what it would be if the infection were allowed to progress naturally through the herd. Decisions concerning planned infections should be made with professional consultation to assure proper handling of the virus and infected animals. It is possible to spread agents other than TGE virus in this way. Improper management could result in swine being infected at the wrong time, or spread to swine other than those intended. Preventing the spread of TGE to other farms is an important responsibility. Dead pigs should be incinerated or kept in a container so they are not available to dogs or vermin that may travel between farms. Workers should not go to other farms or to places where other pork producers gather without a complete change of clothing. The usual question raised by pork producers is how long one should wait before infected or exposed swine can be safely moved into other herds. A common recommendation is that swine should not be moved to other herds for at least 1 month after the last signs are seen in the herd. This period is somewhat arbitrary since it has been shown that virus may actually persist in pigs for longer periods, but no cases of spread from swine sold after such a time have been confirmed. The actual time should be based upon such factors as the need for the sale, the possible consequences of transmitting infection, the possibility of quarantine of the pigs in the herd receiving them, the time of year and an understanding with the new owner. To eradicate TGE and maintain a negative herd, depopulation during a hot month should be accompanied by thorough cleaning and disinfection. Then, after allowing the facilities to be free of swine for several weeks, restocking with serologically negative stock may be effective.

## Porcine Respiratory Coronavirus

A respiratory variant of TGEV, PRCV, has been isolated from pigs of all ages in the United States and Europe. The virus has an altered cell tropism because it grows very well in the epithelial cells lining the respiratory tract, and only to a minimal extent, in small intestinal cells. The virus can be isolated in cell cultures from tonsil and nasal swabs, but rarely from rectal swabs. After the initial infection, PRCV will usually spread to all other pigs on the farm. In Europe, PRCV has been shown to infect pigs on farms several miles away, presumably by aerosol spread. In young pigs, PRCV produces a sub-clinical or mild respiratory infection characterized histologically as a diffuse interstitial pneumonia. No diarrhea is observed in PRCV-infected pigs. The infection may cause slight weight loss, which is rapidly recovered. However, recent information suggests that combined infections of PRCV and other respiratory pathogens such as PRRSV may lead to more severe respiratory disease than infection with each agent alone. In some European countries, the percentage of pigs with TGEV antibody may approach 100%. This high percentage is due to PRCV and not TGEV. Because of this cross-neutralization, pigs tested for TGEV antibodies may give a false positive response. Most regulations governing the import and export of pigs require them

to be free of TGEV antibodies. Pigs testing positive cannot be given a permit. The regulations now allow pigs with antibodies to PRCV, but not to TGEV, to be granted an export permit. Therefore, it is necessary to differentiate between pigs exposed to TGEV and PRCV. At least one imported commercial diagnostic test is available that differentiates between serum from pigs exposed to TGEV or PRCV. Similarly, researchers in the United States also have developed differential reagents and diagnostic serological tests based on U.S. strains of PRCV and TGEV. Limited serological surveys indicate that PRCV infections are increasing in prevalence in the United States. Preliminary cross-protection studies between PRCV and TGEV have produced varying results. Most experimental studies indicate that PRCV infections induce limited protection in pigs against challenge exposure with TGEV unless sows are exposed to PRCV in multiple pregnancies. However, in Europe the widespread prevalence of PRCV infections in swine herds has been accompanied by a concomitant decrease in classical TGE outbreaks. These data suggest that prior exposure to PRCV moderates the severity of TGEV infections in the field at least under the swine management systems used in Europe.

Reference to products in this publication is not intended to be an endorsement to the exclusion of others which may be similar. Persons using such products assume responsibility for their use in accordance with current directions of the manufacturer. The information represented herein is believed to be accurate but is in no way guaranteed. The authors, reviewers, and publishers assume no liability in connection with any use for the products discussed and make no warranty, expressed or implied, in that respect, nor can it be assumed that all safety measures are indicated herein or that additional measures may be required. The user therefore, must assume full responsibility, both as to persons and as to property, for the use of these materials including any which might be covered by patent.

This material may be available in alternative formats.