Salmonella choleraesuis in Pigs
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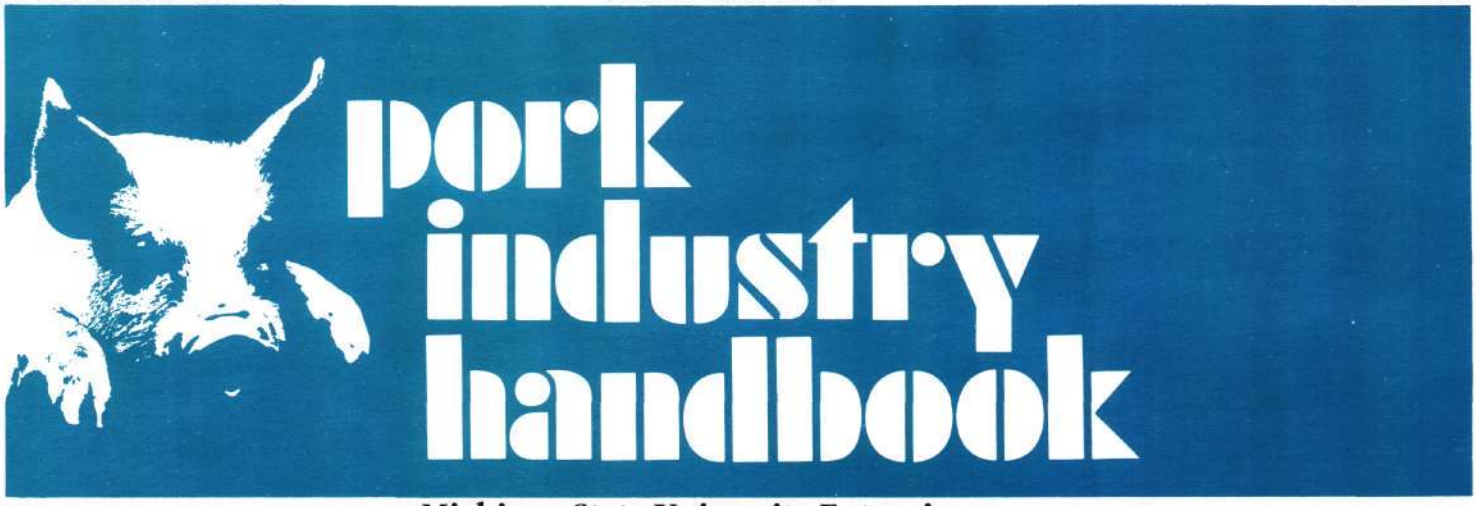

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Salmonella choleraesuis in Pigs

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Salmonellosis continues to have a significant economic impact on the national pork industry. It is estimated that the disease may cost pork producers in the United States more than $100 million annually due to death losses, medication costs and poor weight gain of survivors. Since the mid-1970's, the disease consistently has been one of the most costly in the southeastern United States. The greatest impact in the Midwest has occurred since 1980. In addition, concerns over *Salmonella*-contaminated pork products add to processing and monitoring costs and may impact overall product demand.

Salmonellae were first observed microscopically in 1880 in tissues from humans dying from typhoid fever. The causative organism, *Salmonella typhi*, was cultured in 1884. The first isolation from animals was *Salmonella choleraesuis*, which was cultured in 1885 by Salmon and Smith from pigs that had died of hog cholera. *Salmonella choleraesuis* was considered to be the cause of hog cholera until 1904 when a virus was proven to be the etiologic agent.

Etiology

Salmonellae are gram negative bacteria that are able to survive with or without oxygen and live inside or outside animal cells. The genus *Salmonella* has more than 2,000 serovars or species. *Salmonella choleraesuis* causes 70% to 90% of the cases of salmonellosis in pigs. *Salmonella typhimurium*, the other major cause of porcine salmonellosis in the United States, accounts for 10% to 30% of swine outbreaks. Infection of pigs with other *Salmonella* species may occur, but they only occasionally cause disease outbreaks.

Some authors subdivide *S. choleraesuis* into *S. choleraesuis* and *S. choleraesuis* var *kunzendorf*. Other authors, especially those in human medicine, do not make this distinction. It is interesting that the strain originally isolated by Salmon and Smith, plus the majority of American and British strains isolated before 1920, was *S. choleraesuis*. Since 1920, the majority of swine isolates have been *S. choleraesuis* var *kunzendorf*.

Zoonotic Potential

Salmonella choleraesuis is considered to be host adapted to pigs, meaning that disease due to this organism is limited almost totally to pigs and persistent infections occur without signs of disease. However, *S. choleraesuis* also is an important pathogen of humans even though human disease is relatively rare. This occurs because the organism is very invasive and most infections result in a generalized, life-threatening bacteremia (bacteria in the blood). People who have extensive contact with pigs are infected the least often, with most known disease cases being in people having no known contact with pigs. Most human infections occur when the immune system is compromised by drugs or disease.

Epidemiology

Ingestion of material containing *Salmonella* organisms is the main route of infection for *Salmonella* spp. Infected, carrier pigs shedding salmonellae in their feces are the major source of *Salmonella* infection, between and within herds. Many *Salmonella* spp., such as *typhimurium*, *enteritidis*, *derby* and *agona*, are isolated from feed, rodents and the environment. In contrast, *S. choleraesuis* is rarely, if ever, isolated from feed. Therefore, infected pigs or previously contaminated premises, not feed, are the most likely source of infection for other pigs. Healthy carrier pigs shedding *Salmonella* organisms in their feces are the usual means of introduction into a herd.

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Salmonella choleraesuis is seldom isolated from the feces of healthy pigs. This has made it difficult to determine the initial source of infection in herds without a previous history of infection. Recently *S. choleraesuis* has been isolated from the neutrophils (white blood cells involved in bacterial killing) of healthy pigs, some from herds with no history of salmonellosis. It appears that both healthy and sick pigs can harbor viable *S. choleraesuis* organisms in their neutrophils. Undefined stresses may allow organisms to multiply and cause clinical disease in some animals. Pigs with acute diarrhea due to *S. choleraesuis* excrete up to one million organisms per gram of feces. *Salmonella choleraesuis* has been shown to survive at least 24 days in the water overlay and at least 78 days in the sludge of a water and swine manure mixture. This same species was viable after being buried in an Indiana pasture for 451 days and for up to 120 days in a cattle fecal slurry. It is clear that a single pig with diarrhea can contaminate the environment, infect its penmates and provide a source of infection for future groups of pigs.

Like other *Salmonella* infections, *S. choleraesuis* outbreaks frequently are associated with "stress" factors such as commingling, overcrowding, transportation, inclement weather (environmental), feed changes, parasitism, poor sanitation, aflatoxin in the feed and concurrent disease(s). Morbidity can range from a single animal to more than 50%. In many outbreaks, less than 10% of the group is affected, but a high proportion of affected pigs die.

Weaned pigs less than 5 months of age primarily are affected. However, market weight (220 pounds) and adult pigs occasionally may be affected. Suckling piglets rarely develop clinical disease due to *S. choleraesuis*. The reason for the resistance of nursing piglets is not known; but is thought to be due to maternal immunity acquired via colostrum and milk.

The Disease

Disease due to *S. choleraesuis* consists of acute septicemia (generalized infection of blood and organs) and/or enterocolitis (diarrhea). Acute septicemia without enterocolitis is by far more common. *Salmonella choleraesuis* is the only species that commonly results in acute septicemia in pigs. *Salmonella typhimurium*, the other species that usually causes clinical salmonellosis in swine, generally causes enterocolitis.

Septicemic *S. choleraesuis* infection can result in death without forewarning signs. More commonly, affected pigs are off feed, lethargic, have shallow coughs and high fevers, and their breathing is difficult giving the impression of pneumonia. The ears, tail, nose, feet and abdomen usually become light to dark purple. Affected pigs display posterior weakness, restlessness, paddling or other evidence of neurologic involvement. Pigs that survive 3 or 4 days develop yellow diarrhea containing flakes of fibrin. Affected pigs may continue to eat and drink even with profuse yellow diarrhea. Blood can be present in the stool but is unusual. Animals that recover may have decreased weight gain and loss of profitability.

Diagnosis

Postmortem examination reveals purplish discoloration of the extremities and abdomen, swelling and hemorrhage of lymph nodes, and often small hemorrhages in many tissues. The lungs are fluid-filled, do not collapse, and usually are blue-grey with small hemorrhages. The spleen usually is swollen and dark blue-black. The liver is swollen and blood-filled, and in some cases contains pinpoint white foci. The inner lining of the stomach is dark red to black. Pigs dying of acute septicemia generally have no lesions in the intestine. If the course has been prolonged or in pigs with diarrhea, often there are irregular ulcers and fibrin in the large, and sometimes small, intestine. Rarely, there are shallow, oval ulcers throughout the colon.

Septicemic *S. choleraesuis* must be differentiated from other acute diseases of swine, such as septicemia due to *Erysipelothrix rhusiopathiae*, *Streptococcus suis*, and *Actinobacillus suis*, edema disease due to *Escherichia coli*, pleuropneumonia caused by *Actinobacillus pleuropneumoniae*, mulberry heart disease, and hog cholera. Diarrhea due to *S. choleraesuis* must be differentiated from S. *typhimurium*, swine dysentery, porcine proliferative enteritis, whipworm (*Trichuris suis*) infestation and hog cholera.

The clinical signs combined with postmortem lesions are suggestive of *S. choleraesuis* infection, but by themselves are not diagnostic. Microscopic lesions, especially interstitial pneumonia, and random, focal areas of necrosis in the liver, provide a presumptive diagnosis.

Definitive diagnosis requires isolation and identification of the organism. In most cases, *S. choleraesuis* can be readily isolated from septicemic pigs by directly culturing lung, liver, spleen, kidney and lymph nodes onto blood agar plates and incubating overnight at 37°C. To isolate *S. choleraesuis* from the intestine it is often necessary to inoculate selective and/or enrichment media such as tetrathionate broth. Selenite broth, which is used for culturing many other *Salmonella* spp., may inhibit the growth of *S. choleraesuis*. Isolation of *S. choleraesuis* from the intestine of pigs dying of acute septicemia is difficult and often unrewarding. Lung, liver and spleen are the tissues of choice for isolating *S. choleraesuis* from pigs with acute septicemia. Biochemical and serological tests are used to provide identification of genus and species. An antimicrobial susceptibility test should be obtained to provide guidelines for treatment and control.

Treatment

When treating an outbreak of any disease, the goals are to increase the survival of clinically ill pigs and to prevent the spread of the disease to other pigs. Unfortunately, the attainment of these goals is difficult. Part of the difficulty stems from the fact that *Salmonella* spp, including *S. choleraesuis*, are resistant to many of the antibacterial agents approved for use in swine. Also, many of the bacteria are within the host's cells, and few antibacterial drugs are able to enter animal cells. In many outbreaks, less then 10% of the pigs are affected, so the effectiveness of treatment is difficult to evaluate.

The use of systemic antibacterials to treat septicemic salmonellosis is widely practiced and is felt by most veterinarians and pork producers to decrease the severity of the disease and to increase survival. Injectable products often are required. Mortality in pigs with purplish discoloration is high, but early treatment combined with separation of animals to small hospital pens will increase survival rate. Antibacterial agents should initially be selected on the basis of susceptibility of the majority of *S. choleraesuis* isolates in the geographic area. Bacterial isolation and antimicrobial sensitivity testing in a particular disease outbreak will allow adjustments in therapy.

The use of antibacterial agents to treat *Salmonella* enterocolitis is more controversial. In human medicine, antibacterial agents are used to treat septicemic salmonellosis, but usually not enterocolitis. This is because antibacterial therapy does not decrease the severity of illness and it does increase the duration of *Salmonella* shedding in the feces. Experimentally, antibacterial therapy in swine did not increase the severity of the disease or the duration of *Salmonella* shedding by clinically

affected animals. Antibacterial therapy is viewed by many as beneficial for *Salmonella* enterocolitis. Since *S. choleraesuis* usually causes septicemic disease in pigs, antibacterial therapy is warranted in most, if not all, outbreaks. Antibacterial agents in feed or water reduce the severity of disease caused by experimental *S. choleraesuis* infection. This suggests that oral medication begun early in an outbreak may decrease the number of sick animals.

Management practices to reduce the exposure of pigs to *S. choleraesuis* are important in any outbreak. The most important step is to remove and isolate all sick pigs because they shed large numbers of organisms. Thorough cleaning of the pens and water bowls, covering any gutters that connect adjacent pens, and elimination of traffic from affected to non-affected groups are important. Efforts to reduce and eliminate any stress factors are essential. Pens should be kept dry, clean and well-ventilated. Pigs should be protected from weather extremes and overcrowding, and should be provided with high quality food and fresh, palatable water.

Prevention and Control

Currently, there is no way to prevent introduction of *S. choleraesuis* into a herd since healthy, carrier pigs cannot be accurately identified. Most carrier pigs apparently shed the organism in their feces only infrequently making fecal culture unreliable. Isolation attempts from neutrophils may be a more sensitive method of detecting carriers. The method is difficult, costly and currently used only in research, but may in the future assist in identifying carriers. Blood tests to detect *S. choleraesuis* antibodies help identify pigs that have been exposed to the organism. These tests are rarely used because they cannot differentiate between animals that have eliminated the organism from their system and those which have not. Recent advances in ELISA technology in bovine and swine offer promise in identifying infected individuals and/or herds in the future.

All-in, all-out management systems should be employed, and pigs of different ages should not be commingled. Thorough cleaning and disinfection are important before adding new pigs to empty pens or buildings. Prevention of clinical disease relies heavily on good management and husbandry practices.

The prophylactic use of antibacterial agents in the feed appears to decrease the incidence of clinical disease, but does not prevent infection or eliminate *S. choleraesuis*. If used prophylactically, feed grade antibacterial additives should be used at treatment rather than at growth promoting levels. To prevent the promotion of drug resistance, the same antibacterial drug should not be fed continuously.

Several killed vaccines for *S. choleraesuis* are available commercially. Experimental evidence indicates that killed vaccines increase the number of *Salmonella* organisms required to cause illness, but vaccinated animals do not become completely resistant. Clinical observations indicate that vaccination reduces, but does not eliminate, salmonellosis in the herd. Pork producers should keep in mind that immunity can be overwhelmed by large numbers of organisms. Therefore, management efforts to provide a stress-free environment and to reduce fecal shedding and exposure are still important in controlling *S. choleraesuis* in a vaccinated herd.

Experimental evidence indicates that avirulent, live *Salmonella* vaccines will stimulate stronger, longer lasting immunity than killed vaccines. In many instances, live vaccines stimulate immunity that will totally eliminate *Salmonella* organisms from an animal. There are continued attempts to develop live vaccines that provide solid, long-lasting immunity without causing illness in vaccinated animals. Such a vaccine is not yet available, but at least one has been patented for development.

When attempting to control porcine salmonellosis, the lessons learned from human medicine through attempts to control typhoid fever caused by *S. typhi* should be kept in mind. Millions of dollars have been spent in attempts to develop safe and effective vaccines for typhoid fever, and both living and non-living vaccines are currently in use. Yet typhoid fever has been effectively controlled only in countries and areas where there is a high degree of sanitation. Indoor plumbing and treatment of drinking water to eliminate exposure to *S. typhi* are the only control methods proven to eliminate the disease from a population.

Summary

1. Swine salmonellosis costs United States producers in excess of $100 million annually.
2. The primary cause of swine salmonellosis is *Salmonella choleraesuis* var *kunzendorf*.
3. The organism is transmitted by feces from clinically infected or carrier pigs, or material contaminated with swine feces.
4. A tentative diagnosis is based on clinical signs and post-mortem lesions. Confirmation requires histologic examination and bacterial culture of the organism.
5. Systemic antibacterial drugs provide the most effective treatment in an acute outbreak of septicemic *S. choleraesuis* infection. Antibiotics administered via feed or drinking water may be used to help reduce death loss and reduce the number of clinically affected pigs.
6. Initial selection of antibacterial drugs is based on prior knowledge of the sensitivity of *S. choleraesuis* isolates in a given area.
7. Good management practices to reduce exposure to the organism and to reduce stress on animals are very important in treating and controlling the disease.
8. Current methods do not enable detection of carrier pigs making it extremely difficult to prevent the introduction of *S. choleraesuis* into a herd.
9. Vaccination, in conjunction with good management, may help reduce the incidence and severity of outbreaks.