Tuberculosis and other Mycobacterial Infections

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Background

Swine are susceptible to *Mycobacterium tuberculosis* complex and *M. avium* complex. Tuberculosis caused by *M. tuberculosis* is uncommon in industrialized nations; however disease may be associated with consumption of uncooked garbage containing *M. tuberculosis* or milk contaminated with *M. bovis* in countries in which successful tuberculosis control programs have not been implemented. It is important to note tuberculous lesions in swine due to *M. bovis* have been reported in wild swine in several countries in Europe in recent years. In industrialized countries most tuberculous lesions in swine are caused by bacteria of the *M. avium* complex *(M avium ss hominisuis, M. avium ss avium)* and *M. intracellulare.* Lesions are most often observed in lymph nodes associated with gastrointestinal tract. However, it is important to emphasize some swine may develop progressive disease involving the liver, spleen and other organs of the abdominal and thoracic cavities.

Introduction

Tuberculosis or mycobacterial disease (Tb) is reported in about 0.4% of all swine slaughtered under Federal inspection (based on reports from United States Department of Agriculture, Food Safety and Inspection Service [USDA] and probably costs the swine industry an estimated $7.3 million annually. This is not a large amount compared to losses from other swine diseases. Although there are relatively few commercial herds infected with TB, the economic losses can be devastating to those producers that have the disease in their herds. The disease in swine has no apparent effect on the health of the animal. Lack of transmission of the disease from swine to humans cannot be proven. Therefore, USDA meat inspection regulations formulated in 1972 call for special handling of carcasses in which evidence of lesions containing acid fast bacteria are found. Economic losses occur to the swine industry because of these regulations. Tuberculosis has been nearly eliminated in cattle and poultry. Tuberculin testing of cattle with subsequent slaughter of reactors and in some cases depopulation of entire herds, has lowered the prevalence of the disease to about 0.0001% (USDA, 2010 records) in slaughter cattle., The poultry industry has changed to all-pullet flocks and has essentially eliminated Tb. Elimination of older birds over a year of age has been an effective control measure. The rate of condemnation for Tb is 0.0001% in light fowl (USDA, 2011 records). It has been assumed by many that eradication of Tb from cattle and chickens would ultimately lead to its eradication in swine. This has not occurred and mycobacterial infections in swine remain a problem for pork producers.

Epidemiology

Tuberculosis is transmitted through animal to animal contact or by ingestion of contaminated food, water or soil. *Mycobacterium avium* ss hominisuis and *M. avium* ss avium have been isolated from peat and kaolin and should not be used as feed additives since they are considered high risk factors. Early in the 20th century when Tb in cattle and man was more prevalent, disease in swine was due mainly to *M. bovis* or *M. tuberculosis.* By 1925, *M. avium,* the cause of Tb in birds was reported occur more frequently in swine. The most common serotypes of *M. avium* complex in swine are 1, 2, 4, and 8. Outbreaks of disease due to these serotypes appear to have originated in soil, contaminated litter, sawdust, wood shavings, straw or feces from infected fowl. Isolation of pathogenic mycobacteria other than *M. avium* from swine is uncommon today. From 1985 to 1990, NVSL isolated *M. bovis* from swine originating from 4 premises. In each case these swine were on the same premises with *M. bovis*-infected cattle. The public health significance of *M. avium* complex infections in man is now recognized as the most common secondary bacterial infection in patients with acquired immune deficiency syndrome (AIDS). The bacteria are most often of environmental origin. *M. avium* and other mycobacteria abound in the environment and occur in food and drinking water; therefore it is not surprising that they are present in the human alimentary tract. Thus the alimentary tract could be the source of frequently disseminated *M. avium* infections in patients with AIDS. *Rhodococcus equi* infection in swine also produces a granulomatous lesion that resembles Tb microscopically. The earliest reports of *R. equi* infection in swine were made during the 1930's, and isolation of the organism has been reported frequently since then. *Rhodococcus equi* is common in the soil of hog pens, and infection with this organism occurs about as often in swine with or without mycobacterial disease. The importance of *R. equi* infections to the swine industry is unknown. In summary, although other bacteria can cause diseases resembling swine Tb, *M. avium* ss hominisuis is responsible for a large number of reported cases in commercial herds in countries with *M. bovis* eradication programs. Peat when added to feed or when used as bedding material is considered a very high risk factor for TB in pigs.

Pathogenesis

Swine usually are infected with *M. avium* by ingesting the organism. After ingestion, the organism penetrates the wall of the pharynx near the tonsils or the wall of the small intestine and becomes localized in the mandibular and/or mesenteric lymph nodes. Small lesions develop in these lymph nodes. The health and condition of the infected swine usually are not affected, therefore it is often impossible to establish a clinical diagnosis in these animals. It should also be noted that in herds in which Tb has been diagnosed *M. avium* has been isolated from the lymph nodes of swine that were negative to skin tests, presented no lesions tissues, and had no signs of illness. Tuberculosis in humans due to *Mycobacterium avium ss hominisuis* most often occur in immunocompromised individuals.

USDA Regulations

Lesions (granulomas) in the lymph nodes of infected swine are found at slaughter. These small granulomas are detected by repeatedly sectioning the lymph nodes. Before 1972, tissues with lesions were trimmed and discarded. In 1972, USDA regulation required all carcasses found to have granulomas compatible with Tb to be cooked at 170° F for 30 minutes. For example, if one lesion is found in the mandibular lymph node and one near the mesenteric lymph nodes, a carcass was classified "passed for cooking" or PFC. **This action was taken because tissues of infected swine were suspected as a potential source of infection for humans.** Carcasses processed in this manner lose most of their commercial value (75%), and the additional labor in cooking is an added expense. Also, many processing plants fail to have facilities for cooking; therefore, the carcasses are subsequently condemned. When lesions are found in only one site such as the head or small intestines, the affected part is condemned and the carcass is passed without restriction. Some reports suggest that when wieners were processed at 150° F for at least 10 minutes, 99.9% of added mycobacteria were killed. Subsequently, the FSIS of the USDA proposed a revised set of processing guidelines for PFC carcasses. Since most *M. avium* -infected swine are PFC and few are condemned, these proposed changes to lower the temperature for cooking carcasses would virtually eliminate the Tb problem for pork producers and packers. However, it is important to emphasis that tissues from swine naturally infected with *M. avium* where not utilized. Therefore, they have not been implemented because of anticipated bad publicity for government agencies and the pork industry.

Garbage feeding is a possible, but infrequent source of Tb in countries where Tb in humans and cattle has been reduced to a low level. Because diagnosis of Tb in the live animal is usually impossible, the prevalence of the disease must be determined from postmortem findings by meat inspectors. The prevalence of lesions was about 0.4% in swine slaughtered under Federal inspection. The actual infection rate may be higher since mycobacteria can be cultured from lymph nodes with no visible lesions and because some lesions may go undetected. Moreover, since infection with *R. equi* may be misdiagnosed as that caused by *M. avium,* the reported rate of Tb may be higher than the actual rate. Tuberculous chickens may continue to be a source of infection for swine, although other environmental sources may be more significant. Improper handling of chicken wastes fed to swine also may allow transmission of the disease. Soil and water are other possible reservoirs of infection for swine. Pathogenic mycobacteria may survive for more than 4 years in soil and litter contaminated by chickens with Tb. Studies have shown that sawdust or wood shavings used for bedding are a source of *M. avium ss hominisuis* in swine. *Mycobacterium avium* complex is often found in samples of sawdust and wood shavings where it survives for long periods. The mycobacteria may multiply under proper conditions of moisture and temperature which could explain the seasonal occurrence of disease in some herds. It has been suggested that seasonal changes may produce less favorable conditions for survival of bacteria in wood shavings and thus cause the infection rate to decrease. The presence of lesions in the intestinal wall with subsequent swine-to-swine transmission probably is due to shedding of mycobacteria in the feces. Granulomatous lesions of lungs, mammary glands, and uterus also may occur with the potential for transmission of organisms from these sites. Thus, the addition of infected breeding stock could introduce the disease within a herd, and transmission from infected sows to their litters may maintain the disease within a herd.

Diagnosis

Detection of mycobacterial disease in a live animal is often very difficult, therefore the presence of disease must be determined by post mortem examination. Infection in swine exposed to *M. avium* is usually associated with the lymph nodes of the head and the digestive tract and rarely spreads to other locations. Diagnosis of Tb by physical examination of the live swine is usually impossible. Visual examination of infected sites at slaughter cannot differentiate lesions of Tb from those caused by other microorganisms or conditions; a confirmed diagnosis should be based on mycobactereologic examination from these sites. Diagnosis of Tb in swine on a herd basis is important and usually depends on detection of infected lymph nodes from swine at slaughter. When Tb has been confirmed by microscopic and bacteriologic examinations, the producer should work with a veterinarian to determine potential sources of the infection and alter management practices to eliminate the source if possible. Tuberculin skin testing has been used to identify swine exposed to pathogenic mycobacteria. The amount of tuberculin used and the site of injection have varied depending on the investigator. The recommended method for a tuberculin skin test in swine is an intradermal injection of 0.1 ml *M. avium* purified protein derivative (PPD) in the dorsal surface of the ear. The response (induration) to injection of PPD is observed and recorded at 48 hours. Positive reactions usually include swelling and redness, and they may vary in size and intensity. Hemorrhage and ulceration may occur at the injection site. The reliability of the tuberculin test when used on individual swine has been questioned. The tuberculin test can be used successfully as a herd test although false positive reactions occur. Biologically balanced PPD's of *M. avium* and *M. bovis* may be injected at separate sites on the dorsal surface of the ear to gain useful information on exposure to *M. tuberculosis* complex or to *M. avium* complex organisms. The responses (mm) at the injection sites should be measured (mm) and compared at 48 hours post injection of PPD. Enzyme linked immunosorbent assays have been described for obtaining information on the presence of mycobacterial antibodies in the sera of the swine naturally exposed to clinically significant mycobacteria. However, these tests have not come into widespread use since some animals fail to develop detectable antibodies in the sera for several weeks or months following natural exposure.

Prevention and Control

Control of mycobacterial infection in swine is difficult since no vaccine is available and the preventive use of anti–tuberculosis drugs in feed is either illegal or of unknown value. Preventing the disease in noninfected herds is more effective than trying to eliminate the disease from infected herds. It is important not to raise swine and poultry in close proximity on the same premises. Feeding uncooked garbage, unpasteurized milk, or other materials that might contain viable mycobacteria to swine must be avoided. Breeding stock should be purchased from herds free of Tb (those in which no lesions of Tb are found in slaughter). Efforts should be made to prevent all contact between swine and wild birds. The potential for transmission of *M. avium* complex from infected wild birds to swine is probably low but must be considered. Hogs should not be housed in old poultry buildings unless they have first been thoroughly cleaned and disinfected using tuberculocidal disinfectant. The use of wood shavings sawdust or peat for bedding, especially in farrowing buildings, should be eliminated. Some producers have used wood shavings with no problems, but others have been forced out of business because of Tb. Wood shavings should be kept dry at the sawmill and on the farm and protected from contamination by wild birds and invertebrates. There are few options for eliminating Tb from infected herds. First, producers should not use peat or kaolin as feed supplements. Second, producers may depopulate the herd and then repopulate with stock from Tb- free herds. Little is known about decontamination of infected soil since mycobacteria can survive in this environment for at least 4 years. To avoid such problems, concrete lots should be used whenever possible. Third, concrete surfaces and equipment including farrowing crates and feeders must be disinfected with a cresylic-based disinfectant (one –stroke environ). Quaternary ammonium disinfectants or halogens (e.g., Chlorine) will not kill mycobacteria. Mycobacterial infection will recur if the source of infection cannot be effectively decontaminated or if replacement stock is not separated from the source. Second, producers may choose to endure the 6-month period until all exposed swine have been slaughtered if the source of infection such as infected bedding (e.g., peat) can be determined and eliminated. Mycobacterial disease increases the need for mandatory identification of slaughter hogs. When Tb is diagnosed, a producer is free to send the hogs to slaughter through a public market and request that the packer and other producers share the economic loss. The ability to trace hogs with mycobacterial infection to the herd of origin is useful to solve this problem.

Summary

1. Swine are susceptible to *M. tuberculosis* and *M. bovis* but the primary cause of swine Tb in industrialized countries is *M. avium ss hominisuis* and *M. avium ss avium*
2. Economic loss due to swine Tb is not from death or illness of swine but from the loss of carcasses passed for cooking or condemned.
3. The source of infection for swine may be sawdust, wood shavings, peat, soil, kaolin, water or feces of infected poultry or wild birds and swine or uncooked garbage.
4. *Mycobacterium avium ss hominisuis* and *M. avium ss avium* have been isolated from peat; therefore peat is considered a high risk factor and should not be used as a feed supplement.
5. Tuberculin skin tests are useful in differentiating *M. tuberculosis* complex infected swine and *M. avium* complex infected swine and for gaining information in determining a presumptive diagnosis disease in a herd.
6. A clinical diagnosis of Tb in the live animal is not always possible. To confirm the occurrence of the disease in a herd is best diagnosed by observing probable sites of infection in lymph nodes at slaughter and examining these lesions microscopically and by mycobactereologic examination.
7. No efficacious vaccine is currently available. The disease is best prevented by careful management of swine feed sources and bedding (e.g., wood shavings).
8. *Mycobacterium avium* complex organisms are resistant to anti-Tb drugs; therefore treatment is not recommended.
9. *Mycobacterium avium ss hominisuis* is the most common secondary bacterial infection observed in patients with AIDS.
10. Tuberculocidal disinfectants should be used to decontaminate facilities and concrete surfaces when Tb has been diagnosed in a herd.

For additional information the reader is referred to Chapter 63 entitled: "Tuberculosis" In the tenth edition of <u>Diseases of Swine</u>, published in 2012 by Wiley-Blackwell Publishing, Ames, IA.