Administration of a homologous bacterin to sows pre-farrowing provided partial protection against streptococcosis in their weaned pigs

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Summary

Objective: To determine the efficacy of a *Streptococcus suis* bacterin administered to sows 4 weeks and 1 week before farrowing, in protecting their pigs from clinical streptococcosis when inoculated intravenously at weaning with the homologous strain.

Methods: Ten sows were inoculated intramuscularly in the neck 4 weeks and 1 week prefarrowing, with either 2 mL of a *S. suis* type-14 bacterin (five sows) or 2 mL of a placebo bacterin (five sows). Twenty pigs (two per sow) were weaned at 13 days of age and inoculated with the homologous strain of *S. suis* type 14. Pigs were observed for clinical signs of lameness and meningitis, and humanely euthanized for necropsy and collection of samples for testing, either when moribund or 8 days after inoculation.

Results: The homologous bacterin used in sows pre-farrowing protected their piglets from depression (P=.048), central nervous system signs (P=.019), and microscopic lesions of meningitis (P=.049). There was no difference in mortality, lameness, microscopic lesions of septicemia, or rate of isolation of *S. suis* type 14 from the blood or CSF of piglets from vaccinated or control sows.

Implications: Under the conditions of this study, administration of two doses of a *S. suis* bacterin to sows prefarrowing prevented neurological signs of streptococcosis, but not lameness, bacteremia, or mortality in their progeny from the day of challenge (13 days of age) to 21 days of age.

Keywords: *Streptococcus suis*, swine, meningitis, sow vaccination

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Many of the 35 known serotypes of *Streptococcus suis* cause outbreaks of septicemia and/or meningitis in pigs, especially in weaned pigs.[1,2] To limit economic losses due to *S. suis,* clinically ill pigs are commonly treated with injectable antibiotics and anti-inflammatory agents. Treatment is most successful when sick pigs are recognized and treated early in the course of disease. Practically, the effectiveness of treatment by injection is limited in large herds due to labor constraints.

Streptococcus suis infection of weaned pigs cannot be eliminated by early weaning and age segregation, because piglets are infected during or within hours of birth.[3,4] Additionally, the efficacy of intensive antibiotic therapy in eliminating infection with *S. suis* in carrier pigs is variable and probably strain dependent.[5,6]

Development of approved and effective methods of immunizing weaned pigs against *S suis* are needed. Holt, et al.,[7] reported that two intramuscular inoculations of formalin-killed *S. suis* were sufficient to protect pigs against intravenous challenge. However, a single intramuscular dose of bacterin administered to 4-day-old pigs did not protect them against challenge at 14 days of age with the homologous strain of *S. suis*.[8] Holt, et al.,[9] reported that repeated vaccination with live, avirulent *S. suis* protected pigs against subsequent challenge with virulent strains. Similarly, Busque, et al.,[10] reported that immunization of 4-week-old pigs with live cultures of *S. suis* stimulated protective responses against intravenous inoculation with virulent *S. suis*. The authors do not recommend use of live *S. suis* vaccines because *S. suis* is a zoonotic organism and the risks of introducing a live vaccine strain into a commercial herd have not been well established.

Vaccination against *S. suis* has met with variable success, but has the most potential for benefit if long duration of protection can be achieved at a reasonable cost. Vaccination of sows prefarrowing to stimulate maternal immunity against *S. suis*, if effective, would be an economical alternative to pig vaccination.

Streptococcus. suis type 14 was the most frequent isolate reported in recent outbreaks of streptococcal septicemia, meningitis, and polyarthritis in the United Kingdom.[11] We proposed to determine the efficacy of a *S. suis* type-14 bacterin administered to sows 4 weeks and 1 week prefarrowing, in protecting their progeny from clinical streptococcosis when intravenously (IV) inoculated with the homologous strain of *S. suis* at weaning.

Materials and methods

Study design

Ten clinically normal sows from a single herd, and two pigs from each sow, were used in this study. During 4 years of testing in this herd, *S. suis* type 14 had never been isolated from oropharyngeal and nasal swabs, saliva, skin, or vaginal secretions of sows, or from oropharyngeal secretions, cerebrospinal fluid (CSF), or blood of pigs. On the basis of these results, the herd was considered free of *S. suis* type 14. Herd

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immunity to *S. suis* type 14 resulting from cross-protection between serotypes was considered very unlikely.[12]

Parity-two and parity-three sows from a single farrowing group were randomly allocated to two treatment groups of five sows each.

- An oil-in-water adjuvant was used to prepare a *S. suis* type 14 bacterin and a placebo that contained no *S. suis* antigen. Sows were injected intramuscularly (IM) in the neck 4 weeks and 1 week pre-farrowing with 2 mL of either the *Strep suis* bacterin (Vaccinated sows) or
- the placebo (Control sows). Pigs were not cross-fostered.

At 12 days of age, two barrows from each sow were weaned and moved to Purdue University. Pigs from Vaccinated and Control dams were housed in separate isolation rooms, and inoculated at 13 days of age with the homologous strain of *S. suis* type14 that was included in the bacterin. Pigs were observed twice daily for clinical signs consistent with streptococcosis. All pigs were humanely euthanatized for necropsy and collection of samples for testing, either when moribund, or 8 days after inoculation (21 days of age).

Origin of *Streptococcus suis*

The strain of *S. suis* type 14 used in the bacterin and for pig inoculation was isolated from the CSF of a 14-day-old crossbred pig with severe, fibrinosuppurative leptomeningitis. This pig did not originate from the same herd as the animals used in this study so that pre-existing maternal immunity would not confound the results.

Facilities and diet

Until 12 days of age, pigs were housed on the farm of origin in farrowing crates in an all-in–all-out (AIAO) farrowing room. From 12 days of age onward, pigs from Vaccinated and Control sows were maintained in separate rooms in isolation facilities at Purdue University. Rooms were 3.8 m × 5.2 m (12.5 ft × 17 ft) with sealed, epoxy-coated floors and two drains. Pigs were housed in 1.2 m × 1.8 m (4 ft × 6 ft) elevated pens with plastic-coated expanded metal flooring. Each pen had a plywood comfort board, a 1.2-m (4-ft) long, stainless steel nursery feeder, and one nipple waterer. Rooms were HEPA filtered and ventilated with negative pressure. Pigs were fed ad libitum a commercial diet formulated for early weaned pigs (Metabalance™ 10/15, Consolidated Nutrition L.C.; Omaha, Nebraska), medicated with 400 g per ton chlortetracycline and 35 g per ton tiamulin.

Inoculum preparation and inoculation procedures

A single passage of the *S. suis* type 14 strain used to make the bacterin was grown in liquid growth medium in an atmosphere of 5% CO_2 for 6 hours at 37°C, to a final concentration of 1.4×10^9 colony–forming units (CFU) per mL. Pigs were anesthetized and IV inoculated with 2 mL of bacterial suspension.

Clinical evaluations

Pigs were examined twice daily. Mortality was recorded, and each pig was scored for the presence or absence of central nervous system (CNS) signs (convulsing, stargazing, proprioceptive deficits), lameness, and depression. Depression was defined as lack of response to verbal stimuli or to the caretaker entering the room.

Necropsy procedures and testing

Samples of brain, lung, liver, spleen, and kidney were collected in 10% neutral buffered formalin, processed by routine methods, and examined microscopically. Cerebrospinal fluid and blood were aseptically collected and cultured on 5% sheep blood agar plates. Gram's staining, biochemical testing, and capsular serotyping were performed on at least three colonies per plate. If there was no growth on initial cultures, 100 µL of blood or CSF was enriched by incubating in 8 mL of trypticase soy broth for 18–24 hours at 37°C, and then processing as stated above.

Statistical analysis

Fisher's Exact test was used to compare clinical scores for each clinical sign, and prevalence of septicemia, meningitis, and cultural isolation of *S. suis* type 14 in pigs from Vaccinated and Control sows. A value of $P < .05$ was considered significant.

Results

One pig in the Control group died during IV inoculation and was removed from the study.

Virulence of the *S. suis* isolate was confirmed by inoculation of the susceptible 13-day-old pigs in the Control group. Pigs consistently developed clinical depression, CNS signs, and microscopic lesions of meningitis, and the *S. suis* serotype 14 inoculum strain was repeatedly recovered from the CSF of these pigs from 13 to 21 days of age (Table 1).

The progeny of dams vaccinated at 4 weeks and 1 week prefarrowing with the *S. suis* type-14 bacterin were protected against depression, CNS signs, and microscopic lesions of meningitis when they were IV inoculated with the homologous strain of *S. suis* type 14 at 13 days of age. When pigs from Vaccinated sows were compared to pigs from Control sows, there was no difference in mortality, lameness, microscopic lesions of septicemia, or rate of isolation of the type 14 inoculum strain of *S. suis* from the blood or CSF (Table 1).

Discussion

Under the conditions of this study, the practice of administering two doses of a *S. suis* bacterin to sows prefarrowing provided partial protection of their progeny against clinical streptococcosis after IV inoculation with the homologous strain of *S. suis*. Depression and neurological signs did not occur in nine of ten pigs from vaccinated sows. Swollen joints and lameness occurred in both groups of pigs; however, pigs from Vaccinated sows were lame but mobile, whereas pigs from Control sows were lame and recumbent. Although microscopic lesions of septicemia were not observed in pigs examined from Vaccinated dams, isolation of *S. suis* from the blood of five of ten of these pigs suggested that vaccination did not prevent bacteremia. Presumably, if stressed, these bacteremic pigs might have been susceptible to septicemia resulting in clinical streptococcosis. Dee, et al.,[13] reported that crowding, temperature fluctuations, high relative humidity, and a greater than 2-week age spread among pigs were risk factors for increasing the carrier state of *S. suis* in pigs. Pigs in field conditions would likely be exposed to one or more of these stressors, whereas the laboratory animal housing facility was devoid of these confounding factors. Finally, mortality was not significantly different in pigs from Vaccinated and Control sows.

Failure of sow vaccination to protect pigs against all signs of streptococcosis might be partially due to the IV inoculation

Table 1. Results of vaccinating sows prefarrowing with a *Streptococcus suis* type 14 followed by intravenous inoculation of their progeny with the homologous organism at 13 days of age

Sow treatment, 4 weeks and 1 week prefarrowing:	Pigs from vaccinated sows: *S. suis* type 14 bacterin with oil-in-water adjuvant (5 sows)	Pigs from control sows: oil-in-water adjuvant only (5 sows)	*P* value
Recovery of *S. suis* type 14 from pigs			
cultured blood	5/10 (50%)	6/9 (67%)	.649
cultured from CSF	4/10 (40%)	7/9 (78%)	.169
Clinical signs in pigs			
depression	1/10 (10%)	9/9 (100%)	.048
CNS signs	1/10 (10%)*	6/9 (67%)	.019
lameness	8/10 (80%)	8/9 (89%)	1
mortality‡	1/10 (10%)	4/9 (44%)	.140
Histopathology of pig tissues			
meningitis	1/9 (11%)†	6/9 (67%)	.049
lesions suggesting septicemia	0/9 (0%)†	4/9 (44%)	.082

* Pigs became moribund at day 8 post-inoculation, immediately prior to necropsy
† Tissues from one pig were not processed
‡ Animals euthanized when moribund

procedure, which is a more aggressive challenge of immunity than field exposure. The pathogenesis of *S. suis* infection in the field is not well understood, but presumably, pigs are colonized through oral or nasal exposure, and clinical signs become evident when septicemia occurs subsequent to bacteremia. Although IV inoculation of large numbers of *S. suis* directly into the blood is unlikely to occur in the field, Williams and Blakemore[14] concluded that the clinical signs and distribution of lesions of meningitis after IV inoculation of pigs with *S. suis* were indistinguishable from those from "naturally" occurring cases of *S. suis* meningitis.

In this study, sow vaccination afforded partial protection to 13-day-old pigs given a severe IV challenge with the homologous strain of *S. suis*. Maternal antibodies were presumably responsible for this partial protection. Sow vaccination is an economical alternative to pig vaccination. However, further studies are needed to determine the efficacy of sow vaccination under field conditions, the optimal timing of sow vaccination, and the duration of protection afforded by maternal immunity.

Implications

- Administration of two doses of a *S. suis* bacterin to sows 4 weeks and 1 week prefarrowing reduced clinical signs of depression, neurological signs, and microscopic lesions of meningitis in their progeny from the day of challenge (13 days of age) to 21 days of age.
- There was no statistically significant reduction in lameness, mortality, lesions of septicemia, or rate of recovery of *S. suis* from the blood or CSF of the progeny of vaccinated dams.
- The *S. suis* bacterin for sow vaccination should contain a farm-specific strain of *S. suis* homologous with that recovered from pigs with clinical streptococcosis.

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