RESEARCH REPORT
SWINE HEALTH

Title: The influence of maternal PCV2 immune response on piglet infection rates at weaning and the effect of PCV2 infection at weaning on lifetime performance and vaccine efficacy – **NPB #09-188**

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Industry Summary
With the recent development of porcine circovirus vaccines, porcine circovirus associated disease (PCVAD) has become less of a challenge for swine producers. However, much is unknown about the transmission of the virus from dam to offspring and the effects of viremia at birth on vaccine efficacy. We theorized that viremia at birth would lower vaccine efficacy as measured by growth rate of pigs from birth to 150 days of age. To test this assumption we identified litters that were viremic at birth and matched them with litters that were not virmeic at birth. Within each litter we vaccinated one half of the pigs with a commercial PCV2 vaccine according to label directions and followed the pigs to market. We found that pigs which were viremic at birth were heavier at 14, 84, and 154 days of age compared to non-viremic pigs. As expected vaccine improved weight gain at 154 days of age by 10.96 lbs, but not at other time points. There was no interaction detected between vaccination and viremia at birth meaning that vaccine improved weight gain the same amount regardless of the piglet's infection status at birth. Not surprisingly sows that were viremic at 21 days prior to farrowing were 3.65 times more likely to have a viremic litter. Sow viremia at farrowing was not predictive of piglet infection status. Based on these data, viremia at birth does not influence vaccine efficacy or lifetime growth under the conditions of this study. Control of sow PCV2 infection is not likely to impact growing pig performance.

Keywords: maternal viremia, PCV2, piglet performance

Scientific Abstract
Purpose: With the recent development of porcine circovirus vaccines, porcine circovirus associated disease (PCVAD) has become less of a challenge for swine producers. However, much is unknown about the transmission of the virus from dam to offspring and the effects of viremia at birth on vaccine efficacy. We theorized that viremia at birth would lower vaccine efficacy as measured by growth rate of pigs from birth to 150 days of age.
Methods: In a case control study, serum was collected from 300 sows 21 days prior to and at farrowing. In addition, umbical cord blood was collected from 4 pigs in each litter and pooled within litter after serum separation. All samples were submitted for qPCR analysis of PCV2 and anti-PCV2 antibodies as measured by

IFA to a commercial diagnostic lab. Eight viremic litters were identified and were matched to 8 control litters. Litters were matched based on farrow date, dam parity and antibody titer (at least two-fold higher). Within litter, pigs were blocked to treatment (vaccine, no vaccine) based on birth weight. At weaning pigs were moved to an offsite facility that housed pigs from the same weaning cohort. At weaning and three weeks later pigs were either vaccinated with 2cc of Cirumvent PCV2 (Intervet Schering Plough) or 2 cc of saline. Pigs were weighed at 14, 84 and 154 days of age. Serum samples were collected at 14, 49, 77, 105, 133 and 154 days of age.

Results: Pigs that were viremic at birth were heavier at 14 (4.46 vs. 4.11 kg, SEM 0.08, p=0.002), 84 (45.63 vs. 41.89 kg, SEM 0.60, p=0.001) and 154 (93.9 vs. 89.9 kg, SEM 1.18, p=0.020) days of age compared to non-viremic pigs. Vaccine improved weight gain at 154 days of age by 4.98 kg (94.46 vs 89.4 kg, SEM 1.18 kg, p=0.003) but not at other time points. There was no interaction detected between vaccination and viremia at birth. Dams that were viremic at 21 days prior to farrowing were 3.65 (1.27, 10.55, 95%CI) more likely to have a viremic litter. Sow viremia at farrowing was not predictive of piglet infection status.

Conclusions: Based on these data, viremia at birth does not influence vaccine efficacy or lifetime growth under the conditions of this study. Control of sow PCV2 infection is not likely to impact growing pig performance.

Introduction

With the recent development of porcine circovirus vaccines, porcine circovirus associated disease (PCVAD) has become less of a challenge for swine producers. However, many discussions continue as to the ideal age and frequency of vaccination against this disease. Diaz (2008) demonstrated that maternal antibodies did not influence a piglet's response to vaccination; however, there continues to be much debate (Opriessnig, 2008). One of the primary challenges to elucidating the most effective vaccine strategy is our limited understanding the dynamics of infection within herds. Recently our research group has demonstrated that 75% of piglets had high or moderate levels of maternal PCV antibodies and 1.5% of piglets were qPCR positive at weaning (Connor, World Pork Expo, 2008). These data suggest that 25% of pigs at 21 days of age may be susceptible to PCV2 infection from their weaning cohort. This infection would occur before vaccination can build an effective immune response.

In commercial settings there is not a consistent pattern of infection and antibody responses between herds. Data from large commercial farms has demonstrated that there is tremendous variation between farms in IFA titers to PCV2 in piglets at weaning even when these farms have common management practices and similar sources. Within farms, there is litter to litter variation but within litter variation is limited as demonstrated by 67% of the litters having less than a 3 fold difference between the highest and the lowest IFA titer of three pigs sampled in each litter and high piglet antibodies were generally associated with high circulating dam antibodies. These data would suggest that the dam infection rates are a strong predictor of piglet immunity and possibly infection at weaning. These data did not evaluate the effect of parity, cross-fostering techniques or herd level immunity across all stages of production.

To further understand the optimal timing of vaccine it would be beneficial to understand if high or low antibody levels in dams were predictive of piglet infection and maternally derived immunity at weaning. We theorize that higher levels of maternal immunity will lead to lower rates of piglet infection at weaning. Understanding the effects of maternal immunity on subsequent infection would allow for the design of better breeding herd management protocols and further the development of optimal vaccination strategies in pigs.

Stated Objectives from original proposal

The objectives of this trial are the following:

Phase 1

Evaluate the effect of high and low levels of dam immune response to PCV2 on the probability that at least one pig in the litter is infected (litter infection) with PCV2 at weaning.

Phase 2

Determine the impact of dam immunity (high and low), litter infection with PCV2 status, and vaccination of piglets has on lifetime performance.

Materials and Methods.

Source Herd: Mixed parity sows of common commercial genetics on a 6000 sow commercial farm were used in this study. The farm had a mature parity structure, modern management practices, and had pigs that were free of PRRSv at weaning (confirmed by a statistical sampling of piglets at weaning). Thirty sows were sero-sampled 3 weeks prior to farrowing for IFA titers to PCV2. The samples will be submitted to Iowa State University Diagnostic Facility (Ames, IA) to understand the distribution of maternal antibody levels in the herd.

Phase 1: Three hundred sows were pre-selected for the study prior to farrowing and were serum sampled 3 weeks prior to farrowing. All litters that had attended farrowings and had over 10 pigs born alive were enrolled in the study. Upon farrowing, pigs from each dam were split-suckled within their litter for the first day. Pigs were only transferred off of the sows enrolled in the project and were not part of the study group. A minimum of eight and a maximum of 12 pigs per litter that were in the middle 50% of birth weights (95% confidence of detecting a within litter prevalence of 20%) for that litter were identified, tagged, and remained on that sow until weaning. Stillborn piglets, low viability, and/or mummies were collected from all sows enrolled in the study with more than 4% of the litter born as mummies or more than 20% of the litter born dead. Tissues were harvested for analysis and submitted to Iowa State Diagnostic Laboratory for quantitative PCR for PCV2.

The target pigs from the identified litters were individually identified with ear tags, weighed, and blood collected via navel cord blood sampling pre-suckle at birth and again 5 days prior to weaning (16 days of age via venapuncture). Dams were sampled at the same time as their litters via ear vein sampling. Serum from the pre-weaning piglet samples were submitted to Iowa State University to evaluate serum viral load with qPCR for PCV2 in the piglet samples. For the PCV2 qPCR, 4 pigs within litter were pooled prior to analysis. Infected litters (cases) and two, parity matched non-infected litters (controls) were enrolled in the study. The matched litters consisted of one with a similar ($\leq$ 1 dilution difference 3 weeks prior to farrrowing) and one with a dissimilar ($\geq$3 dilution difference 3 weeks prior to farrowing) in PCV2 maternal IFA titers. The remaining serum samples (piglet birth and post farrowing dam samples) for the enrolled litters were submitted to Iowa State University to evaluate PCV2 IFA titers and serum viral load with qPCR for PCV2.

IFA titers and proportion of PCV2 infected pigs for piglet samples were compared. Within litter agreement for IFA titers were compared for both the birth and weaning samples. Dam IFA titer was used as a predictor of birth and weaning piglet IFA titer and probability of litter infection (viremia) at weaning.

Phase 2: At the time of weaning, pigs from infected litters and two parity matched non-infected litters were moved to an off-site facility. The matched litters consisted of one with a similar ($\leq$ 1 dilution difference) and one with a dissimilar ($\geq$3 dilution difference) in PCV2 maternal IFA. Within litter, pigs were allocated to receive killed PCV2 vaccine (Circumvent™ Killed PCV2 vaccine, 2cc IM, weaning and 21 days later; Scherring Plough/Intervet, Kansas City MO) or a placebo (sterile water, 2 cc IM weaning and 21 days later). Penning was by individual litter. Individual pig weights were captured at 10 and 18 weeks (prior to harvest) post-weaning. All mortalities were recorded and a cause of death was recorded on all mortalities. Serum samples were collected from all pigs at 4, 8, 12, 16 and 18 weeks post weaning for IFA and qPCR analysis. All effects were measured at the litter level and included: lifetime weight gain, post weaning weight gain, post weaning survival rate and survival rate from weaning to market. All effectors of performance on gain were analyzed using the GLM models of SAS and effects on mortality were assessed using logistic regression models.

Results

Phase I

Initial testing of the commercial sow farm demonstrated that 1 litter out of every 10 was PCV2 viremic via qPCR. Based on these results, 300 sows from a single farrowing week were selected for the study. Pigs that were viremic at birth were heavier at 14, 84, and 154 days of age compared to non-viremic pigs (Table 1). PCV2 was not detected in stillborn or mummified piglets via PCR.

Phase 2

Vaccine improved weight gain at 154 days of age by 4.98 kg (Table 2) but not at other time points. There was no interaction detected between vaccination and viremia at birth. Dams that were viremic at 21 days prior to farrowing were 3.65 (1.27, 10.55, 95% CI) more likely to have a viremic litter. Sow viremia at farrowing was not predictive of piglet infection status. There were no differences in mortality post-wean regardless of vaccination; however, pigs that were not viremic at birth had a greater mortality in the finisher. There were no differences in the number of low value pigs at the time the facility began marketing between viremic and non-viremic pigs at birth.

Discussion

Piglets that were viremic at birth had a greater growth rate regardless of vaccination status. The data from this project does not explain these unexpected differences. It could be an undocumented lactation factor that is not reproducible or some form of immunological modulation. We are hesitant to place too much biological significance on the increased weight gain as there is no previously documented explanation for these results. If the results can be replicated in further studies then we believe further mechanistic investigations would be warranted. We are confident that viremia status at birth does not impact lifetime growth as these data fit with casual observation from field cases.

The relationship between pre-farrowing infection status and piglet virema at birth was expected as the virus can pass across the placenta in late gestation. We do not believe based on these data that sow viremia in late gestation has any negative implications on breed to wean farm performance. We have previously reported that PCV2 infection of replacement gilts at the time of breeding or in early gestation can have a significant impact on number of pigs born alive per litter and the number of pigs that were viremic at birth under field conditions (Lowe, 2009). In that case there was no impact on growing pig mortality with high rates of infection at birth.

This data strongly suggests that control of PCV2 transmission in the breeding herd would not have significant impact on growing pig performance if the piglets are vaccinated. In addition, control of PCV2 infection in the breeding herd would not improve performance of pigs vaccinated against PCV2. Based on these data, piglet vaccination strategies can be developed independently from breeding herd PCV2 control plans. Producers and veterinarians should not consider PCV2 infections status at birth as a limiting factor of growth in vaccinated pigs and should not base vaccination decisions of piglets on the infection status of pigs at birth.

Table 1. Impact of viremia at birth on pig live weights at various stages of pig age regardless of vaccination status.

	Viremia at Birth	No Viremia	SEM	P value
Animal wt, kg				
14 days of age	4.46	4.11	0.08	.002
84 days of age	45.63	41.89	0.60	.001
154 days of age	93.9	89.9	1.18	.020

Table 2. Influence of PCV2 vaccination at weaning and 3 weeks post-weaning on pig live weights.

	Vaccinated	Control	SEM	P value
Animal wt, kg	94.46	89.40	1.18	.003