Adsorption of colostral antibodies against classical swine fever, persistence of maternal antibodies, and effect on response to vaccination in baby pigs

Joris Vandeputte, DVM; Henry L. Too, BVSc, MVSc; Fook K. Ng, BVMS; Cindy Chen, DVM; Kim K. Chai, DVM; Guo A. Liao, DVM

Objective—To determine kinetics of antibody absorption, persistence of antibody concentrations, and influence of titers on vaccination of baby pigs with a vaccine against classical swine fever (CSF).

Animals—15 sows and their litters.

Procedure—Farrowings were supervised. Initial time of suckling was recorded. In the first experiment, blood samples were collected at farrowing, 2 and 4 hours after suckling, and hourly until 10 hours after initial suckling. Samples were assayed for CSF antibodies, using a serum neutralizing (SN) test. A second experiment included 33 baby pigs vaccinated as follows: 10 prior to ingestion of colostrum, 18 between 1 and 4 hours after ingestion of colostrum, and 5 at 12 hours after ingestion of colostrum. Fourteen pigs were vaccinated when 7 weeks old, and 15 pigs were not vaccinated. At 10 weeks of age, pigs were challenge-exposed with virulent CSF virus. Blood samples were collected and assayed for CSF antibodies and p125 antigen and p125 antibodies.

Results—CSF antibodies were detected in pigs beginning 2 hours after suckling. Colostal antibodies persisted for >7 weeks (half-life, 79 days). Vaccination of pigs before suckling provided effective protection from severe disease after challenge-exposure. However, vaccination of neonates with antibody titer was not effective, because 19 of 23 (82%) pigs succumbed after challenge-exposure. All pigs vaccinated when 7 weeks old resisted challenge-exposure, whereas all unvaccinated control pigs succumbed.

Conclusions and Clinical Relevance—Vaccination before ingestion of colostrum conferred good protection against CSF in baby pigs. Vaccination of 7-week-old pigs that had decreasing concentrations of passively acquired antibodies was efficacious. (Am J Vet Res 2001;62:1805–1811)

Classical swine fever (CSF), which also is known as hog cholera, remains an important viral disease of pigs in many parts of the world. The disease is caused by a pestivirus within the family Flaviviridae. The clinical disease and its diagnosis have been described. Similar to other noncytopathic pestiviruses, CSF virus expresses a nonstructural protein of approximately 125 kd during replication. Detection of p125 antigen and antibodies against this protein may be used to aid early detection and diagnosis of the disease. In countries in which CSF is endemic, prevention and control depend primarily on vaccination programs, using attenuated live-virus vaccines. Whereas prevention of CSF can be achieved successfully through the use of vaccines, control of the disease in herds in which the disease is endemic appears to be less successful. The major reason for the inability of vaccinations to successfully immunize baby pigs has been ascribed to the persistence of antibodies obtained from the colostrum of immunized dams. Varying numbers of pigs respond positively to vaccination, depending on the antibody titer of the dams (and hence, their colostrum), as well as that of the baby pigs at the time of vaccination. In 1 study, pigs from vaccinated sows were only partially protected when challenge-exposed at 21 and 42 days of age, despite the fact that antibody titers persisting from ingestion of colostrum were sufficient to interfere with vaccination. At 21 days of age, 20% of pigs died following experimentally induced infection, whereas the mortality rate was 50% for 42-day-old pigs after challenge-exposure. In another study, it was reported that vaccination of pigs when 30 to 40 days old resulted in an estimated vaccination success rate of >70%. Because of the interference of antibodies obtained by ingestion of colostrum, it was recommended that pigs from vaccinated sows be vaccinated when 7 to 9 weeks old. Although such recommendations can be made in herds free of CSF, the same cannot be applied without risk in situations in which CSF is endemic. Delaying vaccination until pigs are 7 to 9 weeks old would leave approximately 100% of that cohort of baby pigs susceptible to exposure to virus from endemically infected herdmates and contaminated premises prior to vaccination. In herds endemically infected with CSF, pigs are exposed and may succumb to natural infection when they lose the protection of colostral antibodies. Therefore, in many such herds, even multiple vaccinations of pigs of various ages are unable to control the disease.

To overcome the interference of colostral-derived antibodies on vaccination, it has been suggested that vaccinating pigs prior to or shortly after the intake of
colostrum would avoid the influence of colostral antibodies on vaccination.13-15 The vaccines used in those studies were attenuated live-virus vaccines produced in rabbits. The Rocvac strain of these vaccines was efficacious in pigs when given 3 hours prior to suckling of colostrum from immune dams but not when given immediately prior to suckling. On the other hand, the lapinized Chinese strain was efficacious when given immediately before intake of colostrum from immune dams as well as 1, 2, and 3 hours after suckling of colostrum. However, the time period after suckling colostrum beyond which vaccination of neonatal pigs against CSF would become ineffective was not determined. It may be speculated that efficacy of vaccination would depend on the speed at which antibodies in colostrum are absorbed during the first hours after birth. Lai et al14 found that colostral-derived antibody titers in baby pigs peaked between 9 and 24 hours after colostrum uptake. In another study,16 investigators found that colostral-derived antibodies may persist for up to 3 months in baby pigs, depending on the vaccination program of the dams. They also found that the half-life of maternal antibodies varied from 6 to 17 days, depending on the vaccination program of the sows. In comparison, the half-life for antibodies against pseudorabies was 13 days in pigs that had consumed colostrum from sows vaccinated with the attenuated live-virus (Bartha strain) vaccine and was 10.25 days in pigs that had consumed colostrum from sows vaccinated with an oil-adjuvant inactivated-virus vaccine.17

The study reported here was performed to determine the kinetics of antibody absorption after intake of colostrum, persistence of antibodies, and influence of antibody titers on vaccination of pigs with an attenuated live-virus CSF vaccine produced in an ovine cell line. Another objective of the study was to compare the efficacy of vaccination of pigs before or shortly after ingestion of colostrum with the response to a classic vaccination program in 7-week-old pigs.

Materials and Methods

Animals—Fifteen pregnant purebred Landrace sows were acquired from a herd used for the production of purebred broodstock. The herd was a closed herd and free from pseudorabies. Thirteen sows were in their third parity, and the other 2 sows were in their fourth parity. Thirteen sows had been vaccinated against CSF at 5 to 7 weeks old and received booster vaccinations at 10 to 11 weeks old and before the first insemination (6 to 8 months old). These sows also had been vaccinated approximately 3 to 4 weeks prior to each farrowing. The 2 remaining sows had never been vaccinated against CSF.

All sows received IM injections of prostaglandin F 2α between day 110 and 112 of gestation to induce farrowing during typical daylight working hours. All farrowings were supervised. Pigs were collected as soon as they were born, separated from the dam, and given a unique identification number. When farrowing was completed, pigs were allowed to suckle. Time of initial suckling was designated time 0 for colostrum uptake.

Experimental design—Two experiments were conducted. Experiment 1 included 4 sows that had been vaccinated against CSF. Blood samples were collected from these sows at time of farrowing and from baby pigs at time of birth, 2 and 4 hours after initial suckling, and hourly thereafter until 10 hours after initial suckling. Depending on the number of pigs in each litter, blood samples were collected from 1 or 2 pigs at each collection point; thus, blood was collected from each pig once during the 10-hour period after initial suckling. Sixty-two baby pigs from 11 litters (9 sows that had been vaccinated against CSF and the 2 nonvaccinated sows) were used for experiment 2. Thirty-three pigs were vaccinated IM immediately before intake of colostrum or between 1 and 12 hours after suckling of colostrum during the neonatal period. Of the remaining 29 pigs, 14 were vaccinated after weaning when they reached 7 weeks old, whereas the other 15 were left as unvaccinated control pigs.

Pigs were weaned when they were 4 weeks old and transported to facilities at the Faculty of Veterinary Medicine, Universiti Putra Malaysia. Pigs were randomly allocated to separate isolation rooms. Access to these rooms was strictly limited to authorized personnel. When pigs were 10 weeks old, each was challenge-exposed by IM inoculation of 1 ml of virulent virus suspension containing 10^6 median lethal dose (LD50/ml). Blood samples were collected from each pig immediately before suckling and at irregular intervals after initial suckling.

After challenge-exposure, pigs were monitored daily for signs of illness, and rectal temperatures were recorded. Clinical variables monitored included pyrexia (rectal temperature > 41 C), appetite (rushing to eat during feeding), lethargy and dullness (reluctance to move when handled or provoked), recumbency (inability to stand), signs of nervous system disorders (tremors, poor locomotion, ataxia, convulsions), and skin lesions (discoloration or hemorrhage). Pigs with severe illness were euthanatized by IV injection of pentobarbital sodium. All other pigs were euthanatized on day 21 after challenge-exposure. All pigs were necropsied.

Vaccination—An attenuated live-virus vaccine composed of the Chinese strain produced on a lamb-kidney cell line was used. The vaccine contained 480 median protective dose/animal, as determined by a method described elsewhere. The lyophilized pellet was suspended in an appropriate solvent, and a 2-ml volume was immediately injected IM in the pigs.

Viral exposure—The virus used for challenge-exposure was a virulent strain isolated in Malaysia and designated as DI 201/67. It was prepared by injecting a 10-week-old unvaccinated pig that was seronegative for CSF antibodies. Subsequently, blood samples were obtained from this inoculated pig, and defibrinated blood in aliquots of 5 ml was stored at –70 C. Before challenge-exposure, the LD50 was determined by use of IM inoculation of 10-fold dilutions of the virus stock into 14-week-old pigs seronegative for CSF antibodies. The inoculation dose used was 10^6 LD50/ml, calculated according to the method of Reed and Muench.19

Serologic analysis—Antibodies were determined by use of a serum neutralization (SN) assay, as described elsewhere.20 Briefly, heat-inactivated serum was serially diluted 3-fold, and a volume of 50 µl was placed in each well of a microplate. An equal amount of virus containing 200 to 400 median tissue-culture infective dose/ml was added, and the mixture was incubated at 37 C for 1 hour. After incubation, 150 µl of lamb-kidney cell line (IRO4) cells containing 2 × 10^5 cells/ml were added, and each microplate was placed into a CO2 incubator at 37 C for 3 days. After incubation, CSF virus in cell cultures was determined by an indirect immunofluorescence test using a commercially prepared CSF monoclonal antibody and anti-mouse fluorescein isothiocyanate conjugate. Titer for the SN assay was determined as the last well of the serially diluted serum that had 100% neutralization of the CSF virus, and it
were detected, using a commercially prepared ELISA kit.  Briefly, sera were placed in wells of a microplate sensitized with the hog cholera virus (HCV) p125 protein. After 1 wash, anti-HCV P125 monoclonal antibody peroxidase conjugate was added. Excess conjugate was eliminated by a second wash. Amount of enzyme linked to the immune complex was revealed by addition of a substrate.

Detection of p125 antigen—Serum p125 antigens were detected, using an indirect ELISA kit.  Briefly, sera were placed in wells sensitized with anti-HCV p125 monoclonal antibody. After 1 wash, anti-HCV p125 rabbit antiserum was added. After a second wash, goat anti-rabbit immunoglobulin-peroxidase conjugate was added. After a third wash, the amount of antigen was revealed by addition of a substrate.

Statistical analysis—Half-life of maternal antibodies was calculated on the basis of results for sera obtained from nonvaccinated neonatal pigs and pigs vaccinated when 7 weeks old that were obtained from 4 sows that had been vaccinated against CSF. Correlation between antibody titers of sows and baby pigs and half-life of colostral antibodies was analyzed by use of a linear-regression method. Effect of vaccination on development of seroneutralizing antibodies was calculated by use of an ANOVA and contrast analysis. For all tests, values of \( P < 0.05 \) were considered significant.

Results

AdSORBATION OF COLOSTRAL ANTIBODIES IN NEONATAL PIGS—Seroneutralizing antibodies were detected in baby pigs by 2 hours after initial suckling (Table 1). Antibody titers increased steadily and reached a peak between 5 and 7 hours after initial suckling. Antibody titers of pigs equaled or exceeded titers of their dams, except for those of pigs from 1 sow. Four, 7, and 10 hours after initial suckling, correlation between the titer of the sows and their pigs were 0.83 (\( P = 0.08 \)), 0.68 (\( P = 0.14 \)), and -0.15 (\( P = 0.78 \)), respectively.

Persistence of colostral antibodies—In all groups of pigs from seropositive sows, antibody titers determined by use of the SN assay decreased steadily until pigs were 10 weeks old (Fig 1). Calculated half-life of colostral antibodies ranged from 6.8 to 9.3 days (mean, 7.9 days).

Influence of colostral antibodies on antibody titers of vaccinated pigs—Pigs that were not vaccinated and that were from seronegative sows remained seronegative, but pigs that were vaccinated before ingestion of colostrum had significantly higher titers (GMT, 2.76) than those of similarly vaccinated pigs in litters from vaccinated sows (GMT, < 0.48). The same pattern was observed for 10-week-old pigs. Titers of pigs vaccinated at 7 weeks of age did not differ significantly between those from nonvaccinated (GMT, 0.48) and vaccinated (GMT, 0.75) sows.

Detection of p125 antibodies—Pigs from vaccinated sows had colostral antibodies against protein p125. The number of seropositive pigs decreased steadily from birth until pigs were 10 weeks old. In pigs from nonvaccinated sows, production of p125 antibodies was induced when vaccination was given prior to uptake of colostrum but not when vaccination was performed at 7 weeks of age. After challenge-exposure, all pigs that survived were seropositive for p125 antibodies (Table 4). In contrast, all but 1 of the pigs that succumbed after challenge-exposure were seronegative.

Detection of p125 antigen—The p125 antigen was detected in 4 of 10 pigs that did not survive challenge-exposure. However, the antigen was not detected in all 17 pigs that survived challenge-exposure (Table 5).

### Table 1—Antibody titers (log₁₀) to classical swine fever (CSF) virus in vaccinated sows and their neonatal pigs

<table>
<thead>
<tr>
<th>Sow†</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.88</td>
<td>0.48</td>
<td>1.44</td>
<td>1.92</td>
<td>1.92</td>
<td>1.92</td>
<td>1.92</td>
<td>1.92</td>
<td>1.92</td>
<td>1.92</td>
</tr>
<tr>
<td>2.4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.96</td>
<td>0.96</td>
<td>1.44</td>
<td>1.44</td>
<td>1.44</td>
<td>1.44</td>
<td>1.44</td>
</tr>
<tr>
<td>1.92</td>
<td>0.0</td>
<td>0.0</td>
<td>0.96</td>
<td>0.96</td>
<td>1.44</td>
<td>1.44</td>
<td>1.44</td>
<td>1.44</td>
<td>1.44</td>
</tr>
<tr>
<td>0.96</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.96</td>
<td>1.44</td>
<td>1.44</td>
<td>1.44</td>
<td>1.44</td>
<td>1.44</td>
</tr>
</tbody>
</table>

Values reported are log₁₀, as determined by use of a serum neutralization assay.

*Time 0 = Time of farrowing. †Samples obtained immediately before farrowing.
Viral exposure of pigs—All 15 unvaccinated control pigs succumbed to disease between days 9 and 17 after challenge-exposure. They were pyrectic (rectal temperature exceeded 41 C as early as day 2 after viral exposure) for 7.6 to 10.5 days. Pigs were anorectic and reluctant to move. Abnormal neurologic signs, tremor, and ataxia were evident in 10 pigs between day 7 and 14 after viral exposure. Ecchymotic and petechial hemorrhages could be observed in the skin as early as day 5 after exposure and persisted until pigs died or were euthanatized.

Nineteen of 23 pigs vaccinated between 1 and 12 hours after colostrum uptake died or were euthanatized between 14 and 21 days after viral exposure. Twelve of these 19 pigs had signs of nervous system disorders. Pigs in this group were anorectic and lethargic, but these signs were less pronounced than in the group of unvaccinated control pigs. Similar to the unvaccinated control pigs, hemorrhages in the skin were detected.

The 4 pigs vaccinated between 1 and 12 hours after colostrum uptake that survived challenge-exposure were pyrectic for a mean of 4.5 days. They were lethargic and anorectic beginning on day 3 after viral exposure but recovered completely. One pig vaccinated 1 hour after colostrum uptake completely recovered by day 10 after viral exposure. This pig had a 7-day peri-
Table 4—Detection of p125 antibody in sows and their pigs vaccinated with an attenuated live-virus vaccine and response to challenge-exposure with a virulent strain of CSF virus at 70 days of age

<table>
<thead>
<tr>
<th>Vaccination program of pigs</th>
<th>Sows†</th>
<th>70 d</th>
<th>77 d</th>
<th>91 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before ingestion of colostrum</td>
<td>Yes (3)</td>
<td>0/6 ND ND ND ND ND 0/4 ND 0/4 ND 0/4 ND 1/1 1/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NC No (2)</td>
<td>0/4 ND ND ND ND ND 0/4 ND 0/4 ND 0/4 ND 0/4 ND 0/4 ND 0/4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After ingestion of colostrum</td>
<td>1 h Yes (4)</td>
<td>0/3 0/4 ND ND ND ND ND 0/4 0/4 ND 0/4 ND 1/1 1/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 h Yes (3)</td>
<td>0/3 0/2 0/2 ND ND ND ND 0/4 0/4 ND 0/4 ND 0/4 ND 0/4 ND 0/4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 h Yes (3)</td>
<td>0/4 0/1 ND 1/4 ND ND ND ND 0/5 0/5 ND 0/5 ND 0/1 2/5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 h Yes (3)</td>
<td>0/4 ND ND ND ND 3/5 ND ND 0/5 0/4 ND 0/5 ND 1/1 1/5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 h Yes (3)</td>
<td>0/4 ND ND ND ND 4/5 4/5 0/2 0/5 0/4 0/5 0/4 1/3 0/5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 wk Yes (5) ND (1)</td>
<td>0/5 ND ND ND ND 2/2 5/7 0/2 1/9 3/7 0/9 2/3 5/5 10/10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not vaccinated</td>
<td>No (2)</td>
<td>0/4 ND ND ND ND 0/4 ND 0/4 0/4 ND 0/4 ND 0/4 ND 0/4 ND 0/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NC No (2)</td>
<td>0/4 ND ND ND ND 0/4 ND 0/4 0/4 ND 0/4 ND 0/4 ND 0/4 ND 0/3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*No. with positive results/No. tested. The p125 antibody was detected (Yes) or was not detected (No) in samples obtained from the sows at time of farrowing.† NC = Negative control sows that were not vaccinated against CSF virus.

See Table 2 for remainder of key.

Table 5—Detection of p125 antigen in pigs vaccinated with an attenuated live-virus vaccine and response to challenge-exposure with a virulent strain of CSF virus at 70 days of age

<table>
<thead>
<tr>
<th>Vaccination program of pigs</th>
<th>p125 antigen in pigs (time after birth)*</th>
<th>Survival after challenge-exposure†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before ingestion of colostrum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaccinated</td>
<td>ND ND 0/4 6/6</td>
<td></td>
</tr>
<tr>
<td>Nonvaccinated</td>
<td>ND ND 0/4 4/4</td>
<td></td>
</tr>
<tr>
<td>After ingestion of colostrum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 h Vaccinated</td>
<td>ND ND 0/1(survivor) 1/4</td>
<td></td>
</tr>
<tr>
<td>2 h Vaccinated</td>
<td>ND ND ND 0/4</td>
<td></td>
</tr>
<tr>
<td>3 h Vaccinated</td>
<td>ND ND 0/1 2/5</td>
<td></td>
</tr>
<tr>
<td>4 h Vaccinated</td>
<td>ND ND 0/1 1/5</td>
<td></td>
</tr>
<tr>
<td>12 h Vaccinated</td>
<td>0/5 1/4 1/4 0/5</td>
<td></td>
</tr>
<tr>
<td>7 wk Vaccinated</td>
<td>0/5 0/4 0/6 0/5</td>
<td></td>
</tr>
<tr>
<td>Nonvaccinated</td>
<td>ND ND 0/4 10/10</td>
<td></td>
</tr>
<tr>
<td>Not vaccinated</td>
<td>0/7 2/4 0/2 0/12</td>
<td></td>
</tr>
<tr>
<td>Vaccinated</td>
<td>0/3 ND 0/1 0/3</td>
<td></td>
</tr>
</tbody>
</table>

*No. with positive results/No. tested. The p125 antigen was detected (Yes) or was not detected (No) in samples obtained from the pigs at 70 days of age.
† NC = Negative control pigs that were not vaccinated against CSF virus.

See Table 4 for key.

Discussion

Severity of disease induced here was high and consistent with experimentally induced infections described by others.14,25 In nonvaccinated control pigs, rectal temperature was high (> 41 °C), and the febrile episode developed more quickly than in vaccinated pigs. Duration of illness ranged between 7 and 13 days. Hemorrhages and petechiae of the skin and abnormal neurologic signs considered typical for CSF were frequently observed. Abnormal neurologic signs are common1 but were not described in other challenge-exposure studies.14,15,23 In contrast, Koenen and Lefebvre5 reported that contact infection results in a much milder disease with some pigs not having any of the typical signs reported here.

Results of the study reported here documented that vaccination of neonatal pigs from vaccinated sows prior to allowing them to suckle colostrum provides effective protection. Indeed, these pigs were protected from the severe disease caused by viral challenge given during which it was pyrexic, anorectic, lethargic, and trembling. Two pigs vaccinated 3 hours after colostrum uptake were pyrexic and anorectic for 4 days before complete recovery by day 9 after viral challenge. One pig vaccinated 4 hours after colostrum uptake had a biphasic febrile reaction. Apart from being slightly lethargic, anorectic, and pyrexic, this pig did not have other clinical signs and recovered completely by day 10 after viral exposure.

All pigs vaccinated prior to consumption of colostrum survived challenge-exposure to the CSF virus. Three of 10 pigs vaccinated before colostrum uptake appeared dull, lethargic, and anorectic, and they were completely anorectic for 2 or 3 days. However, none of the 3 pigs had signs of nervous system disorders or skin lesions. Mean duration of clinical illness was 7.25 days, and they completely recovered. The remaining 7 pigs in this group did not have signs of illness.
pigs when they were 10 weeks old. Some pigs had transient clinical signs, similar to those described by Lee et al\textsuperscript{1,2} in pigs that were challenge-exposed when they were 1, 2, or 3 months old. In another study\textsuperscript{9,10}, in which investigators used the same virus as Lee et al\textsuperscript{11} for challenge-exposure of 8-week-old pigs, none of the pigs vaccinated before intake of colostrum had clinical signs or died from the disease. In our experiments, 3 pigs were considered clinically affected after viral challenge-exposure, whereas 3 others were not. This finding may have been attributable to the severity of the viral challenge that was used as well as the field strain of virus used, which differed from those of other studies.\textsuperscript{11,12} Indeed, the differences observed between those 2 studies confirm that the same challenge-exposure performed on pigs of differing ages may result in a slightly different clinical picture when considering fever, dullness, and anorexia.

Vaccination of neonates that have colostral antibodies cannot be regarded as effective, although some of the pigs vaccinated 1, 3, or 4 hours after initial colostrum uptake survived challenge-exposure. Again, this is not consistent with results of another study.\textsuperscript{9} Apart from the difference in the virus used for the challenge-exposure, another reason for these differing results may be found in the speed of absorption of the colostral antibodies. In the study reported here, concentration of colostral antibodies reached a peak by 5 to 7 hours after initial suckling, compared with 9 to 24 hours in that other study.\textsuperscript{10}

Vaccination of 7-week-old pigs was efficacious in all groups and confirmed results of other studies in which the same vaccine was used in pigs from vaccinated sows.\textsuperscript{16,24} Protection from challenge-exposure was almost complete, because all pigs remained alert including the 2 pigs that had increased rectal temperatures for 1 and 2 days, respectively. Any remaining colostral antibodies apparently did not interfere with the response to vaccination.

Vaccination should prevent or limit clinical disease, but it should also limit or prevent circulation of virus in the swine population. This is particularly important when vaccination is used as a means for eradication of viral disease.\textsuperscript{1} Analysis of results of the study reported here strongly suggests that the vaccine prevented viremia after challenge-exposure in pigs vaccinated at 7 weeks of age and those vaccinated before the uptake of colostrum. Indeed, p125 antigen was not detected in these groups. The p125 antigen is only produced during virus replication,\textsuperscript{25} and its detection is a strong indication for viremia. It has been documented that the vaccine is able to prevent viremia and dissemination of virus after challenge-exposure.\textsuperscript{26} In the latter study, the vaccine almost completely prevented the replication of virulent virus after challenge-exposure in tonsils of 6-week-old pigs with detectable colostral antibodies.

The fact that protection from the virulent Malaysian strain used here is as good as the protection reported by investigators who used European strains\textsuperscript{27,28} corroborates the generally accepted opinion that the CSF strains do not have major antigenic differences. To our knowledge, the findings reported here represent the first evidence that confirms efficacy of this vaccine against an Asian strain.

Uptake of antibodies was rapid during the first 4 hours after ingestion of colostrum and seemed to be complete by 6 hours after ingestion. Colostral antibodies persisted for >7 weeks, and the half-life was almost 8 days. Although vaccination prior to uptake of colostrum did not induce seroconversion in pigs from vaccinated sows, it protected pigs from challenge-exposure. Vaccination of neonates also did not induce seroconversion, and the protection against challenge-exposure was limited.

In our study, administration of the vaccine induced antibody titers similar to those observed by others.\textsuperscript{11,16,25-28} It also had a strong priming effect, which was documented by the anamnestic response in sero-neutralizing and p125 antibodies in pigs that survived challenge-exposure but not in pigs that were not protected. These results confirm earlier observations\textsuperscript{10} that sows in infected areas may have high concentrations of antibodies, probably as a result of infection following vaccination, such that 8-week-old pigs can have amounts of residual colostral-derived antibodies sufficient to interfere with the response to vaccination. Therefore, it has been proposed that clinicians should postpone vaccination of pigs in those circumstances.

In the pigs that were not protected from challenge-exposure, seroconversion was not detected during the 21-day period after challenge-exposure. This is in agreement with observations in another study\textsuperscript{9} in which investigators documented the slow development of detectable antibodies after infection with CSF virus in pigs that had not been primed by vaccination or infection.

In our experience, vaccination of pigs with the vaccine used in the study reported here will induce p125 antibodies only after booster vaccinations are given. In the study reported here, all vaccinated sows were given the same vaccine at least 3 times, which explains the p125 antibodies in sera of sows and their pigs. The p125 antibodies from colostral origin disappeared almost in parallel with the decrease of the corresponding sero-neutralizing antibodies. Vaccination of pigs that were from nonvaccinated sows prior to ingestion of colostrum resulted in induction of p125 antibodies, as determined on the basis of positive results at 7 weeks but not at 14 days. Unfortunately, data are not available between these 2 time points. On the contrary, vaccination of 7-week-old pigs from nonvaccinated sows did not result in induction of p125 antibodies. One reason could be that a period of 3 weeks between vaccination and collection of blood samples was not a sufficient interval for seroconversion to be detected. A more likely hypothesis is that replication of vaccine virus in newborn pigs is more intensive and, hence, produces more p125 antigen than in 7-week-old pigs. However, we are not aware of any data that exist to confirm this hypothesis. In pigs from vaccinated sows, vaccination prior to ingestion of colostrum did not cause seroconversion to p125 antigen. This probably was attributable to the interference of colostral-derived antibodies. Analysis of these results indicates that detection of p125 antibodies should not be used to
confirm whether pigs have been successfully vaccinated against CSF.

We conclude that the vaccine used in the study reported here is capable of conferring good protection against a virulent Asian strain of CSF virus in baby pigs vaccinated before the uptake of colostral antibodies. Analysis of these results also confirms that vaccination of 7-week-old pigs with declining concentrations of colostral-derived antibodies is efficacious.

References