Clinical evaluation of intradermal vaccination against porcine enzootic pneumonia (Mycoplasma hyopneumoniae)


The aim of the present study was to investigate the efficacy of single-dose intradermal vaccination against Mycoplasma hyopneumoniae on a commercial swine unit. A total of 1051 healthy suckling piglets of 28±3 days of age were randomly assigned to one of three experimental groups: (a) intradermal: 346 piglets vaccinated intradermally (Porcilis M Hyo ID Once, Intervet SPAH), (b) intramuscular: 351 piglets vaccinated intramuscularly (Porcilis M1 Intervet SPAH) and (c) controls: 354 piglets injected with a placebo (adjuvant only). Performance parameters such as average daily weight gain (ADG), as well as health parameters and lung lesion scores were monitored from four weeks of age until slaughter. The improvement in ADG over the controls, during the finishing phase, was 27 g/day for the intradermal group and 17 g/day for the intramuscular group. Both intradermal and intramuscular vaccinations were effective in reducing clinical signs and lung lesions caused by M hyopneumoniae. Compared with the controls, approximately 10.4 per cent fewer clinical cases were diagnosed in the intradermal group, and 6 per cent fewer in the intramuscular group, during the finishing period.

In conclusion, performance results were better in the vaccinated groups than in the control group, while intradermal vaccination afforded greater protection than intramuscular vaccination, especially with regard to morbidity, lung lesion and pleuritis scores.

Mycoplasma hyopneumoniae is one of the most common pathogens detected in pigs with respiratory disease (Jones and others 2004) and the sole aetiological agent of mycoplasmal pneumonia. However, under field conditions, various other agents are involved and the term enzootic pneumonia (EP) is used to describe the disease (Thacker 2006). EP, probably one of the most important and common porcine respiratory diseases in intensive swine units, is a chronic disease that causes major economic losses to the global swine industry. The disease is characterised by low mortality and high morbidity (including clinical respiratory signs such as prolonged non-productive coughing), and the detrimental effects of EP are mainly associated with treatment costs, reduced performance in growing and finishing pigs, and the consequent lower market price of the carcase. At postmortem examination, areas of consolidation in the ventral parts of the api
cal, cardiac and diaphragmatic lung lobes are frequently seen adjacent to the normal tissue (Jackson and Cockcroft 2007, Sibila and others 2007). The reduction in the average daily gain (ADG) and the lower carcass weight are correlated with the increase in pneumonic lung lesions (Pommier and others 2000). Superimposed secondary infections by Pasteurella multocida or other pathogens (such as Bordetella species, Actinobacillus species) are quite common, adding to the economic losses (Thacker 2006).

Although major efforts have been made to control M hyopneumoniae infection, significant losses due to EP remain (Thacker 2006, Maes and others 2008). In many countries, more than 70 per cent of the swine herds are vaccinated against M hyopneumoniae. Different vaccination strategies have been adopted, depending on the type of herd, the production system and management practices, the infection pattern and the preferences of the producers. Initially, double intramuscular vaccination was practised most frequently, but in recent years, single-dose vaccines have come to the market and can be more easily incorporated into management routines (Dawson and others 2002, Baccaro and others 2006). A single-dose scheme is popular because it requires less labour and can be more easily incorporated into management routines (Dawson and others 2002, Baccaro and others 2006). Intradermal injection is an advanced, but seldom used, method of vaccination (Bernardy and others 2005). The immune response induced by intramuscular or subcutaneous administration of vaccines has been studied much more intensively than that induced
following intradermal injection. But the skin is better adapted to inducing an immune response because of the recognition, processing and presentation of antigen by epidermal dendritic cells. Moreover, there is evidence that intradermal vaccination is able to induce a mucosal and cell-mediated immune response (Aitken and others 1992, Chin and others 1996, Enioutina and others 2000, Matsushima and others 2005, Jones and others 2004, Martelli and others 2007). This means that the intradermal route may be suitable for inducing both types of immunity in several intracellular and mucosal infections. The lack of information about intradermal vaccination has resulted in only a limited number of commercial products becoming available (Bernardy and others 2008). Intradermal vaccines against \( M. \) hyopneumoniae have not been commercially available until recently.

The aim of this study was to evaluate the efficacy of an inactivated intradermal single-dose aqueous \( M. \) hyopneumoniae vaccine against EP in a commercial pig herd, based on pneumatic lesions and performance parameters.

Materials and methods

Study herd

The study was carried out on a commercial 900-sow farrow-to-finish farm in northern Greece, with its own feed mill and slaughterhouse. The farm was shown to be positive for \( M. \) hyopneumoniae by the presence of typical lung lesions in more than 95 per cent of 30 slaughtered pigs examined before the beginning of the trial. The mean lesion score was 19 (according to the method described by Goodwin and Whittlestone [1973], full data not presented). Typical clinical signs of EP such as non-productive cough and occasional dyspnoea were obvious, especially in the growing and fattening pigs. Previous serology had also proved the presence and circulation of \( M. \) hyopneumoniae infection (data not presented).

Experimental design

The trial was carried out according to a randomised, partially blinded (farm and pathology laboratory personnel were unaware of the treatment allocations and the sampling) placebo-controlled design. The healthy piglets of three weekly production batches, approximately 125 litters, were included. A total of 1051 healthy suckling piglets of 2-5 days of age were randomly assigned to one of three treatment groups, as follows: each piglet within a litter was weighed and ear-tagged and given one or other of the three treatments, which were allocated in strict sequence. Maintaining the same sequence for all the litters resulted in the three treatment groups. The animals were housed in pens of 25 piglets. The pens, with tubular metal partitions, had slatted or semislatted floors, depending on the production stage. Ventilation and climate were controlled electronically in order to optimise the temperature and humidity for each stage of production.

At the start of the trial, 346 piglets (equal numbers of four-week-old males and females) comprised the intradermal treatment group, receiving a single intradermal 0.2 ml dose (using an automatic needleless injector, Intervet Intradermal Vaccinator) of an aqueous vaccine containing inactivated cells of \( M. \) hyopneumoniae strain 11 with a light paraffin oil and dl-a-tocopherol acetate-based adjuvant (Frocilis M Hyo ID Once, Intervet SPAH). A further 351 piglets comprised the intramuscular treatment group, receiving 2 ml of the Frocilis M1 intramuscular vaccine (Intervet SPAH) which contains an inactivated whole cell concentrate of \( M. \) hyopneumoniae strain 11 inducing a mean antibody titre in mice of \( \geq 5.6 \) log. 2.

The control group (C) consisted of another 354 piglets which received 0.2 ml of the placebo (dl-a-tocopherol acetate-based adjuvant) either by intramuscular (178 piglets) or by intradermal injection (176 piglets). Runs and piglets showing signs of disease were excluded. All the animals were fed and managed as usual for the farm and remained mixed at random throughout the trial period. All male piglets in the study were castrated at four days old in accordance with Directive 120/2008 (Council of the European Union 2008). Injectable (intramuscular) antibiotics (eg, enrofloxacin and lincomycin) were only used in piglets which developed severe disease.

Follow-up of study animals

The animals were observed for local reactions (eg, redness, spots and oedema at the injection site) and systemic reactions (eg, listlessness, drowsiness and shivering) for 24 hours following treatment.

The piglets were next weighed when they were transferred from the nursery unit (at about 60 to 65 days of age) and again at slaughter (at about 165 days of age). In the slaughterhouse, the lungs of all pigs were scored for lesions associated with \( M. \) hyopneumoniae infection, according to the method described by Goodwin and Whittlestone (1973). Pleuritis lesions were also scored as follows: Grade 1 – no lesions, Grade 2 – topical lesions (spots) and Grade 3 – larger areas of adhesion.

Mortality and morbidity (animals requiring individual injectable antibiotic treatment) were recorded throughout the trial period, including the details of identity, date, disease and medication. Dead piglets underwent postmortem examination to establish the cause of death. The average daily gain (ADG) was calculated for individual animals for three periods – nursery (admission to end of nursery), finishing (end of nursery to slaughter) and for the whole total period (admission to slaughter).

Serology samples were collected for serology at vaccination and at slaughter from 30 piglets per treatment group, selected at random. The samples were examined by blocking ELISA (\( M. \) hyopneumoniae ELISA, DAKO) for the presence of antibodies against \( M. \) hyopneumoniae (Feld and others 1992). Sera with optical density (OD) values \( \geq 50 \) per cent of the OD buffer control were considered positive. OD values 50 to 65 per cent of the OD buffer control were classified as inconclusive. OD values \( \geq 65 \) per cent of the OD buffer control were recorded as negative. Inconclusive serology results (OD values 50 to 65 per cent of the OD buffer control) were also considered as negative for the statistical analysis.

Statistical analysis

The individual pig was the statistical unit. Previous studies in this herd had demonstrated an ADG of about 550 g/day with a standard deviation of about 60 g/day. The significance level (\( \alpha \)) was set at 0.05 which, with a group size of 350, and at a power of 80 per cent, should be sufficient to detect a treatment effect of 15 g/day. The proportion of healthy lungs (lesion score 0), pleuritis lesions, morbidity, mortality and the serological results were evaluated in contingency tables using Pearson’s chi-squared tests. The distribution of the animals across the pens (nursery, growing and finishing) was not recorded.

The lesion and pleuritis scores were compared between treatment groups by the non-parametric rank sum test. The Bonferroni method was used to correct for multiple comparisons. The hypothesis testing of the lung lesion and pleuritis scores were carried out using the Kruskal-Wallis test. Dunn’s method was used to correct for multiple comparisons.

Weight gain and bodyweights were evaluated using analysis of covariance (Proc GLM), using treatment and gender as independent variables and the bodyweight on the day before vaccination as covariate. Dunnett’s test was used to compare the intradermal group with the intramuscular and control groups.

The statistical software used was the SAS Statistical Package (the SAS System release for WINDOWS – 2001; site no. 0084912001/SAS Institute).

Results

The ADG results and the bodyweight data are summarised by group as shown in Table 1. The ADG during the finishing period and the ADG over the total period were significantly higher in the intradermal- and intramuscular-vaccinated pigs compared with the controls. The improvement in the intradermal group over the control group was 27 g/day during the finishing phase and 23 g/day over the whole period. The average weight at slaughter in the intradermal group was 3.7 kg better than in the controls. There were no significant differences between the intradermal and intramuscular groups with respect to these weight gain parameters.

Morbidity results are presented in Table 2. The number of piglets showing clinical signs in the intradermal and intramuscular groups was very similar during the nursery period. However, during the finishing period, the morbidity level in the intradermal group was 3.7 kg better than in the controls.
group was significantly lower than in both the intramuscular and the control groups. The most frequent cause of morbidity during the nursery period was classified as ‘diarrhoea’ (74 per cent), followed by ‘cough–respiratory signs’ (6 per cent) and ‘neurological signs’ (6 per cent). ‘Cough’ and/or ‘dyspnoea’ were (was) recorded in 74 per cent and ‘diarrhoea’ in 21 per cent of the affected animals during the finishing period.

The mortality results are summarised in Table 3. Due to mortality or other reasons (e.g., severe gastrointestinal disease), 16 pigs from the intramuscular group, 23 from the intradermal group and 32 from the control group did not reach slaughter age. Mortality during the nursery period occurred mainly due to ‘enteritis’, ‘Escherichia coli’ and other enteritis. Mortality during the finishing period mainly occurred due to ‘enteritis’, ‘Escherichia coli’ enteritis’ and/or ‘oedema disease’ (91 per cent of deaths). During the finishing period, the diagnosis of ‘M. hyopneumoniae’ and ‘P. multocida’ was made in the majority of postmortem examinations, while there were three cases of ‘ileitis’ (11 per cent) and one case of ‘enteritis’ (4 per cent).

The lung lesion and pleuritis scores are presented in Table 4. Lung lesion scoring revealed a significant improvement in the intradermal group over the intramuscular and control groups. The mean score of the intramuscular group was significantly lower than that of the control group. The prevalence of lungs with pleuritis was 60 per cent in the control group, 47 per cent in the intramuscular group and 26 per cent in the intradermal group.

The serological results at vaccination were used as an indication of the level of maternally derived antibody. Differences in serology between the vaccinated and control pigs at slaughter were a measure of the level of maternally derived antibody. Differences in serology between the intradermal and intramuscular groups with the same dose of antigen at roughly the same dose level (though with a different dose volume and route of administration) and the same adjuvant. The intradermal vaccination was found to produce a significantly better improvement in parameters such as morbidity (fewer treatments) and lung lesion score when compared with the intramuscular group. In particular, there was a benefit in the control group in reducing the clinical signs and lung lesions due to M. hyopneumoniae infection. This study confirmed and extended previous findings (Jones and others 2004) of the positive effects of intradermal vaccination against M. hyopneumoniae under field conditions. However, it is noticeable that single-dose intramuscular vaccination proved efficacious under the same conditions, but not to the same degree as single-dose intradermal vaccination (there was a better humoral response in the intradermal group).

The occurrence of scroscopic piglets in the control group at the end of the trial showed that non-vaccinated piglets also produced a detectable humoral response to natural infection, suggesting that control pigs had been in contact with M. hyopneumoniae during the trial period. The occurrence of more scrotopositive animals in the intradermal and intramuscular groups than those in the control group is an indication of vaccine-induced seroconversion. The results obtained indicate that both vaccines are capable of eliciting a detectable humoral immune response to M. hyopneumoniae after vaccination. Additionally, vaccination with the intradermal or intramuscular vaccine resulted in a significantly lower lung lesion score at slaughter and considerably more animals without lung lesions in the vaccinated groups than in the control group. Such results, as Baccaro and others 2006 have also suggested, might be due to immune stimulation and lower M. hyopneumoniae excretion.

From a clinical viewpoint, the direct comparison between intradermal and intramuscular vaccination of piglets against M. hyopneumoniae was of significant interest in the present study. Both vaccines contain the same M. hyopneumoniae antigens at roughly the same dose level (though with a different dose volume and route of administration) and the same adjuvant. The intradermal vaccination was found to produce a significantly better improvement in parameters such as morbidity (fewer treatments) and lung lesion score when compared with the intramuscular group. In particular, there was a benefit in the mean score of EP-compatible lung lesions of nearly 47 per cent for the intradermal group and 18 per cent for the intramuscular group. In particular, there was a benefit in the mean score of EP-compatible lung lesions of nearly 47 per cent for the intradermal group and 18 per cent for the intramuscular group. In particular, there was a benefit in the mean score of EP-compatible lung lesions of nearly 47 per cent for the intradermal group and 18 per cent for the intramuscular group.

In order to explain the differences in clinical observations between the intradermal and intramuscular groups, it is suggested that the intradermal route of administration may induce a different type and extent of immune response to the intramuscular route (Bernard and others 2008). It has already been reported that intradermal injection induces both cell-mediated and antibody-mediated immune responses (Martelli and others 2007). The results of this study support the hypotheses that either the intradermal vaccine can induce other mechanisms in addition to the circulating antibodies involved in protecting the respiratory tract, or it leads to a different type of immune response due to the more effective presentation of the antigen by the dendritic cells. To be validated, these theories need to be supported by further focused in vitro and in vivo observations.

Discussion

According to the results of this study, the intradermal and the intramuscular single-dose vaccination of piglets at the age of around four weeks proved effective at improving the performance and reducing the prevalence and severity of lung lesions in a farrow-to-finish swine unit compromised by M. hyopneumoniae infection. Previous studies with other intramuscular vaccines (Formmier and others 2000, Kyrilakis and others 2001) have also shown the efficacy of intramuscular vaccination in reducing the clinical signs and lung lesions due to M. hyopneumoniae infection. This study confirmed and extended previous findings (Jones and others 2004) of the positive effects of intradermal vaccination against M. hyopneumoniae under field conditions. However, it is noticeable that single-dose intramuscular vaccination proved efficacious under the same conditions, but not to the same degree as single-dose intradermal vaccination (there was a better humoral response in the intradermal group).

The occurrence of scrotopositive piglets in the control group at the end of the trial showed that non-vaccinated piglets also produced a detectable humoral response to natural infection, suggesting that control pigs had been in contact with M. hyopneumoniae during the trial period. The occurrence of more scrotopositive animals in the intradermal and intramuscular groups than those in the control group is an indication of vaccine-induced seroconversion. The results obtained indicate that both vaccines are capable of eliciting a detectable humoral immune response to M. hyopneumoniae after vaccination. Additionally, vaccination with the intradermal or intramuscular vaccine resulted in a significantly lower lung lesion score at slaughter and considerably more animals without lung lesions in the vaccinated groups than in the control group. Such results, as Baccaro and others 2006 have also suggested, might be due to immune stimulation and lower M. hyopneumoniae excretion.

From a clinical viewpoint, the direct comparison between intradermal and intramuscular vaccination of piglets against M. hyopneumoniae was of significant interest in the present study. Both vaccines contain the same M. hyopneumoniae antigens at roughly the same dose level (though with a different dose volume and route of administration) and the same adjuvant. The intradermal vaccination was found to produce a significantly better improvement in parameters such as morbidity (fewer treatments) and lung lesion score when compared with the intramuscular group. In particular, there was a benefit in the mean score of EP-compatible lung lesions of nearly 47 per cent for the intradermal group and 18 per cent for the intramuscular group. Nevertheless, it must be noted that for other parameters, the differences were not significant. Apparently, there are many variables to be considered, in conjunction with a veterinarian who has an overall knowledge of the herd’s health status, before deciding between intradermal or intramuscular vaccines.

In order to explain the differences in clinical observations between the intradermal and intramuscular groups, it is suggested that the intradermal route of administration may induce a different type and extent of immune response to the intramuscular route (Bernard and others 2008). It has already been reported that intradermal injection induces both cell-mediated and antibody-mediated immune responses (Martelli and others 2007). The results of this study support the hypotheses that either the intradermal vaccine can induce other mechanisms in addition to the circulating antibodies involved in protecting the respiratory tract, or it leads to a different type of immune response due to the more effective presentation of the antigen by the dendritic cells. To be validated, these theories need to be supported by further focused in vitro and in vivo observations.

Table 1: Average daily gain (g/day) by period and by experimental group (mean±sd), and average bodyweights (kg) at each weighing and by experimental group (mean±sd)

<table>
<thead>
<tr>
<th>Period</th>
<th>Trial group</th>
<th>Mycoplasma hyopneumoniae intradermal (n=346)</th>
<th>Mycoplasma hyopneumoniae intramuscular (n=351)</th>
<th>Control (n=354)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery period</td>
<td>47±2.95</td>
<td>45±2.86</td>
<td>46±2.98</td>
<td>60±3.14</td>
</tr>
<tr>
<td>Finishing period</td>
<td>666±3.15</td>
<td>647±3.36*</td>
<td>640±3.17†</td>
<td>600±3.13†</td>
</tr>
<tr>
<td>Total period</td>
<td>623±3.33*</td>
<td>605±3.34†</td>
<td>600±3.13†</td>
<td></td>
</tr>
<tr>
<td>Average bodyweights</td>
<td>6.4±1.3</td>
<td>6.4±1.3</td>
<td>6.3±1.2</td>
<td>9.9±5.5§</td>
</tr>
<tr>
<td>At vaccination</td>
<td>Νumber of diseased pigs/number of pigs in the group (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Respiratory</td>
<td>M. hyopneumoniae intradermal</td>
<td>M. hyopneumoniae intramuscular</td>
<td>Control</td>
</tr>
<tr>
<td></td>
<td>Intradermal</td>
<td>71/336 (20.5%)†</td>
<td>74/335 (21.1%)†</td>
<td>78/334 (22.0%)†</td>
</tr>
<tr>
<td></td>
<td>Intramuscular</td>
<td>7/67</td>
<td>22</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>78/336 (22.0%)†</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>End of nursery</td>
<td>22.8±3.8</td>
<td>22.4±3.6</td>
<td>22.4±3.9</td>
<td></td>
</tr>
<tr>
<td>At slaughter</td>
<td>103.2±5.4†</td>
<td>100.5±5.5§</td>
<td>99.5±5.3†</td>
<td></td>
</tr>
</tbody>
</table>

1) *Values with different superscripts in the same row differ significantly (P<0.05)

Table 2: Number of clinically diseased pigs and percentage (morbidity) by period, indication and experimental group

<table>
<thead>
<tr>
<th>Period</th>
<th>Trial group</th>
<th>Mycoplasma hyopneumoniae intradermal</th>
<th>Mycoplasma hyopneumoniae intramuscular</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery period</td>
<td>71/336 (20.5%)†</td>
<td>74/335 (21.1%)†</td>
<td>78/334 (22.0%)†</td>
<td></td>
</tr>
<tr>
<td>Finishing period</td>
<td>7/67</td>
<td>22</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>78/336 (22.0%)†</td>
<td>92</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) *Number of diseased pigs/number of pigs in the group (%)
the conditions of this field study, the particular intradermal injection allowed simple and accurate dosing with minimum effort. Under intradermal vaccination using an automatic needleless injector comfort signs such as movement and vocal reactions) standpoints, and cost of labour) and animal welfare (less tissue damage and discomfort) of this study, it can be suggested that, under the field conditions in this study, intradermal vaccination can significantly reduce the prevalence and severity of *M hyopneumoniae*-associated pneumonia and pleuritis lesions. The single-dose intramuscular vaccine also proved efficacious against *M hyopneumoniae*, but the intradermal product performed better in respect of morbidity and lung lesion score. The differences observed between the two vaccinated groups support the proposal that intradermal vaccination can be more effective than intramuscular vaccination in reducing the severity of *M hyopneumoniae*-induced lung lesions, probably due to the more effective presentation of antigen to the immune system. Both vaccines significantly reduced the negative effects of *M hyopneumoniae*-associated pneumonia on performance. Thus, the intradermal vaccine tested in this study can be considered more efficacious against *M hyopneumoniae* than the intramuscular vaccine.

**Acknowledgements**

Lung lesional scoring was performed by the Laboratory of Pathology, School of Veterinary Medicine Aristotle University of Thessaloniki, Greece. Serological tests were performed in the Department of Reproduction, Obstetrics and Herd Health, Faculty of Veterinary Medicine, University of Ghent, Belgium. All trial materials were supplied by Intervet SPAH, Boxmeer, The Netherlands, which also funded the trial through the Research Committee of the Aristotle University of Thessaloniki, Greece (to C. Alexopoulos and E. Tzika).

**References**


**Figure 1:** Serological results at vaccination and at slaughter by treatment group. **Adm** Admission, **Sl** Slaughter

**Table 3:** Number and percentage of dead pigs (mortality rate) by period and by experimental group

<table>
<thead>
<tr>
<th>Period</th>
<th>Trial group</th>
<th>Mycoplasma hyopneumonia intradermal</th>
<th>Mycoplasma hyopneumonia intramuscular</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery period</td>
<td>Respiratory</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>11</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11/346 (3.2%)</td>
<td>15/351 (4.3%)</td>
<td>18/354 (5.1%)</td>
</tr>
<tr>
<td>Finishing period</td>
<td>Respiratory</td>
<td>3</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5/335 (1.5%)</td>
<td>8/336 (2.4%)</td>
<td>14/336 (4.2%)</td>
</tr>
</tbody>
</table>

*Number of dead pigs/total number of pigs in the group (mortality rate) [P<0.05, there is no statistical difference. *Values with identical superscripts in the same row do not differ significantly (P>0.05).]

*Values with different superscripts in the same row differ significantly (P<0.05)."

**Table 4:** Number of lungs with lesions associated with enzootic pneumonia at slaughter and mean (±sd) lung lesion scores and pleuritis scores by experimental group

<table>
<thead>
<tr>
<th>Lung lesion score/trial group</th>
<th>Mycoplasma hyopneumonia intradermal (n=215)</th>
<th>Mycoplasma hyopneumonia intramuscular (n=119)</th>
<th>Control (n=110)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesion score &gt;0 Mean (±sd) score</td>
<td>7.03±6.9*</td>
<td>10.75±7.2†</td>
<td>13.3±7.3†</td>
</tr>
<tr>
<td>Pleuritis score/trial group</td>
<td>67</td>
<td>127</td>
<td>142</td>
</tr>
<tr>
<td>Spots (score=2)</td>
<td>17</td>
<td>23</td>
<td>44</td>
</tr>
<tr>
<td>Larger adhesions (score=3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Values with different superscripts in the same row differ significantly (P<0.05)."
Papers


Clinical evaluation of intradermal vaccination against porcine enzootic pneumonia (Mycoplasma hyopneumoniae)


Veterinary Record published online January 18, 2012
doi: 10.1136/vr.100239

Updated information and services can be found at:
http://veterinaryrecord.bmj.com/content/early/2012/01/18/vr.100239.full.html

These include:

References
This article cites 17 articles, 2 of which can be accessed free at:
http://veterinaryrecord.bmj.com/content/early/2012/01/18/vr.100239.full.html#ref-list-1

P<P
Published online January 18, 2012 in advance of the print journal.

Email alerting service
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Notes
Advance online articles have been peer reviewed, accepted for publication, edited and typeset, but have not not yet appeared in the paper journal. Advance online articles are citable and establish publication priority; they are indexed by PubMed from initial publication. Citations to Advance online articles must include the digital object identifier (DOIs) and date of initial publication.

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/