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Vaccination with a genotype 1 modified live vaccine against porcine reproductive and respiratory syndrome virus significantly reduces viremia, viral shedding and transmission of the virus in a quasi-natural experimental model

Emanuela Pileri [a,b,*], Elisa Gibert [b], Ferran Soldevila [b], Ariadna García-Saenz [b], Joan Pujols [b], Ivan Diaz [b], Laila Darwich [a,b], Jordi Casal [a,b], Marga Martín [a,b], Enric Mateu [a,b]

[a] Departament de Sanitat i Anatomia Animals, Universitat Autònoma de Barcelona, 08193 Bellaterra, Cerdanyola del Vallès, Spain
[b] Center de Recerca en Sanitat Animal (CReSA), UAB-IRTA, Campus de la Universitat Autònoma de Barcelona, 08193 Bellaterra, Cerdanyola del Vallès, Spain

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ABSTRACT

The present study assessed the efficacy of vaccination against genotype 1 porcine reproductive and respiratory syndrome virus (PRRSV) in terms of reduction of the transmission. Ninety-eight 3-week-old piglets were divided in two groups: V ($n = 40$) and NV ($n = 58$) that were housed separately. V animals were vaccinated with a commercial genotype 1 PRRSV vaccine while NV were kept as controls. On day 35 post-vaccination, 14 NV pigs were separated and inoculated intranasally with 2 ml of a heterologous genotype 1 PRRSV isolate ("seeder" pigs, SP). The other V and NV animals were distributed in groups of 5 pigs each. Two days later, one SP was introduced into each pen to expose V and NV to PRRSV. Sentinel pigs were allocated in adjacent pens. Follow-up was of 21 days. All NV (30/30) became viremic after contact with SP while only 53% of V pigs were detected so (21/40, $p < 0.05$). Vaccination shortened viremia (12.2 ± 4 versus 3.7 ± 3.4 days in NV and V pigs, respectively, $p < 0.01$). The 50% survival time for becoming infected (Kaplan–Meier) for V was 21 days ($CI_{95\%} = 14.1–27.9$) compared to 7 days ($CI_{95\%} = 5.2–8.7$) for NV animals ($p < 0.01$). These differences were reflected in the R value as well: 2.78 ($CI_{95\%} = 2.13–3.43$) for NV and 0.53 ($CI_{95\%} = 0.19–0.76$) for V pigs ($p < 0.05$). All sentinel pigs (10/10) in pens adjacent to NV + SP pens got infected compared to 1/4 sentinel pigs allocated contiguous to a V + SP pen. These data show that vaccination of piglets significantly decrease parameters related to PRRSV transmission.

* Corresponding author at: Departament de Sanitat i Anatomia Animals, Universitat Autònoma de Barcelona, 08193 Bellaterra, Cerdanyola del Vallès, Spain. Tel.: +34 935811047; fax: +34 935813297.
E-mail addresses: emanuela.pileri@cresa.uab.cat (E. Pileri), elisa.gibert@cresa.uab.cat (E. Gibert), ferransolde@gmail.com (F. Soldevila), ariadna.garcia@cresa.uab.cat (A. García-Saenz), joan.pujols@cresa.uab.cat (J. Pujols), ivan.diaz@cresa.uab.cat (I. Diaz), laila.darwich@uab.cat (L. Darwich), jordi.casal@uab.cat (J. Casal), marga.martin@uab.cat (M. Martín), enrich.mateu@uab.cat (E. Mateu).

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1. Introduction

Porcine reproductive and respiratory syndrome virus (PRRSV) is probably the most costly among the common diseases of pigs. Recent estimates from Europe and North America indicate that the reproductive efficiency of infected herds is decreased about 1.4 weaned pigs/sow or 1.7 sold feeder pigs/sow (Holtkamp et al., 2013; Nieuwenhuis et al., 2012). To these figures it has to be added the cost caused by increased mortality, excess medication, loss of productive days, etc. As a matter of fact, about 50% of the cost of the disease can be attributed to the impact on weaners and grower pigs (Holtkamp et al., 2013).

Control of PRRSV relies in four different aspects: early diagnosis and monitoring, biosecurity, herd management and immunization. At present, several commercial vaccines (including live attenuated and inactivated) are marketed but their efficacy is considered to be only partial, in the sense that vaccinated animals can be infected if confronted to a heterologous strain. Given the genetic diversity of PRRSV (Murtaugh et al., 2010), in practical terms all challenge situations in the field can be considered as heterologous.

Most often PRRSV vaccines are applied to the breeding herd because vaccination is efficient in preventing reproductive problems although does not avoid completely the development of viremia in sows (Scortti et al., 2006a,b). In contrast, vaccination of piglets is more controversial. Firstly, because respiratory disease caused by PRRSV, particularly by genotype 1 isolates, is not always overt (Martínez-Lobo et al., 2011) and depends on the interaction with other pathogens (Van Gucht et al., 2004). Therefore, the beneficial effect of vaccination is more difficult to evaluate. Secondly, because when a high proportion of viremic piglets arrive to the weaning units, the time needed to induce an effective immunity is probably longer than the time needed for the infection to spread to the majority of animals.

In recent years, the notion of the need of regional or area-wide strategies for controlling PRRS is gaining importance (Corzo et al., 2010). This is particularly true for areas of high pig density where the risk of re-introduction of the virus from external sources (e.g. by proximity) is important. In such circumstances, any intervention leading to the decrease of the likelihood of transmission of the virus within or between farms is positive for the purpose of controlling the infection. Thus, vaccination could significantly contribute to the control of the infection if: (a) decreased the probability of being infected and, (b) reduced the efficiency of vaccinated animals to transmit the infection in the event of getting infected. If vaccines were able to fulfill these requirements, vaccination should result in a decrease in the proportion of infected pigs among vaccinated animals because of a reduction of the reproduction ratio (R) (namely the expected number of secondary cases produced by a single infected individual). Actually, eradication of other important swine infections such as Aujeszky's disease virus has been achieved in many countries by the use of vaccines that were not 100% protective in virological terms but that reduced R significantly below 1 (Bouma, 2005).

In the case of PRRSV, very few studies (Charpin et al., 2012; Mondaca-Fernández et al., 2007; Nodelijk et al., 2000, 2001; Velthuis et al., 2002) dealt with the evaluation of virus transmission either to vaccinated or to unvaccinated pigs and, in some cases, the results were obtained using viruses of different genotype for vaccination and challenge (Nodelijk et al., 2001). Moreover, most models used direct inoculation of vaccinated pigs which is probably very far from the natural way of contagion. Interestingly, when a model of contact between infected and vaccinated or naïve pigs was used, R was below 1 even among unvaccinated pigs, probably because of the low virulence of the isolate (Mondaca-Fernández et al., 2007).

The present study was designed to assess the transmission of genotype 1 PRRSV in vaccinated piglets using a contact model resembling natural conditions for transmission with a well-characterized wild type strain. Also, the course of the infection in vaccinated and unvaccinated pigs was evaluated in order to determine how vaccination could contribute to the decrease of viral shedding.

2. Materials and methods

2.1. Animals and experimental design

Fig. 1 summarizes the design of the experiment. Ninety-eight three-week-old piglets (Landrace × Pietrain) were obtained from a PRRSV and Aujeszky's disease virus negative farm. Animals were vaccinated at weaning (3 weeks of age) against *porcine circovirus type 2 (PCV2)* and *Lawsonia intracellularis*. The experiment was approved by the Ethics Commission for Human and Animal Experimentation of the Universitat Autònoma de Barcelona and by the Departament de Medi Ambient i Habitatge (n° 5796) of the Autonomous Catalan Government.

The experimental facilities were conventional weaning units with physical separation between rooms (solid walls, no air filtering). No other animals than those included in the study were housed for the duration of the experiment. After arrival to the experimental farm, piglets were left to acclimatize for 1 week. Animals were ear-tagged and randomly divided (random numbers) in two groups, designated as V ($n = 40$) and NV ($n = 58$) that were housed in separated rooms with no physical contact between them. V pigs were administered intramuscularly a 2 ml dose of a commercial modified live PRRSV vaccine (MLV) (PORCILIS PRRS® MSD Animal Health) according to manufacturer instructions. Group NV was left unvaccinated and remained as naïve controls. On the 35th day post-vaccination (dpv), 14 NV pigs were separated, housed in an isolated room and inoculated intranasally with 2 ml (1 ml/nostril) of a suspension containing $10^{5.5}$ $TCID_{50}$/ml of a genotype 1 PRRSV strain designated as 3267 (Darwich et al., 2011; Díaz et al., 2012; Gimeno et al., 2011). The inoculated animals were designated as "seeder" pigs (SP). In parallel, the remaining V and NV animals were distributed in groups of 5 pigs each allocated in seven rooms, four of them allocating V pigs and three allocating NV animals. In each room two groups of animals were housed but direct physical contact between pens within the same treatment was avoided by using continuous pen