Susceptibility of swine cells and domestic pigs to SARS-CoV-2

David A. Meekins, Igor Morozov, Jessie D. Trujillo, Natasha N. Gaudreault, Dashzeveg Bold, Bianca L. Aritaga, Juergen A. Richt

Key points

- Cultured swine cells are susceptible to SARS-CoV-2, but domestic pigs are resistant to infection.
- Pigs are unlikely to be carriers of SARS-CoV-2 or relevant pre-clinical animal models for the development of COVID-19 vaccines or therapeutics.

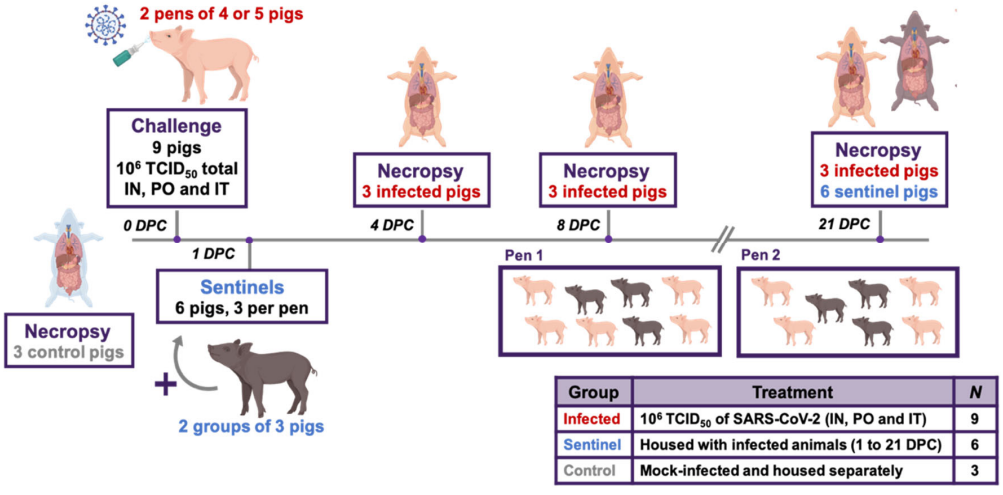
The emergence of SARS-CoV-2, the virus that causes COVID-19, has resulted in a global pandemic with significant morbidity, mortality, and economic consequences. The susceptibility of different animal species to SARS-CoV-2 is of significant concern due to (i) the potential for human-to-animal transmission of the virus, and (ii) the urgent need for pre-clinical animal models that replicate the human disease for the development of effective vaccine and therapeutic countermeasures against COVID-19.

Determining the susceptibility of domestic pigs to SARS-CoV-2 is of particular concern since they are an important livestock species and in close interaction with humans. Additionally, pigs are an excellent research model for studying human infectious diseases based on their relatedness in terms of anatomy and immune response. Several studies suggested that pigs could be susceptible to SARS-CoV-2 based on molecular analysis of the pig ACE2 virus receptor responsible for viral entry into cells. If susceptible, domestic pigs could serve as potential virus carriers and as an important pre-clinical model to understand SARS-CoV-2 virulence and develop countermeasures. To establish the susceptibility of pigs to SARS-CoV-2, we determined the ability of the virus to (i) replicate in cultured porcine cell lines, (ii) establish infection in domestic pigs by experimental oral/intranasal/intratracheal inoculation, and (iii) transmit to co-housed uninfected pigs.

To determine the susceptibility of cultured swine cells to SARS-CoV-2, two different cell lines (swine testicle, ST cells; porcine kidney, PK-15 cells) were inoculated with the virus. No obvious cytopathic effect, indicative of viral infection, was observed during the first passage on these cells. However, clear cytopathic effect was observed on the second virus passage for ST cells and the fourth passage for PK-15 cells. These results indicate that cultured swine cells are indeed susceptible to SARS-CoV-2 infection.

To determine the susceptibility of domestic pigs to SARS-CoV-2, nine six-week-old pigs were inoculated with a high dose of SARS-CoV-2, orally, intranasally, and intratracheally simultaneously. In addition, six uninoculated sentinel pigs were co-mingled with the inoculated pigs one day after infection to determine if the virus could be transmitted between animals. The pigs were monitored daily for signs of disease; however, no increase in body temperature or clinical signs were observed in either the principal inoculated or co-mingled sentinel pigs over the 21-day study period. To detect viral replication in the pigs, reverse-transcription quantitative PCR was used to detect the viral genomic material in nasal, oropharyngeal, and rectal swabs, blood, and in lung tissue collected post-mortem. No viral RNA was detected in any swabs, blood samples, or tissue samples tested, with the exception of a single nasal swab being positive at 1-day post-infection; this was likely residual RNA material from inoculation. In addition, no macroscopic or microscopic pathological changes were observed in any of the respiratory tract tissues collected. Lastly, no SARS-CoV-2-specific immune response was detected in any of the primary inoculated or sentinel pigs during the course of the study and no neutralizing antibodies developed in any pigs.

The results described above clearly indicate that certain pig cells, but not pigs, are susceptible to SARS-CoV-2 infection. The susceptibility of cultured swine cells to SARS-CoV-2 might indicate that different inoculation routes, different pig breeds, or unforeseen genetic changes in the SARS-CoV-2 genome may result in a better compatibility of SARS-CoV-2 for pigs. However, our results indicate that pigs are unlikely to become carriers of SARS-CoV-2 and are not suitable as pre-clinical animal models for the development of novel vaccines or therapeutics.



Group	Treatment	N
Infected	10^6 $TCID_{50}$ of SARS-CoV-2 (IN, PO and IT)	9
Sentinel	Housed with infected animals (1 to 21 DPC)	6
Control	Mock-infected and housed separately	3

Figure 1. Study Design. Eighteen pigs were placed into three groups. Group 1 (n=9, infected) inoculated via intranasal (IN), oral (PO), and intratracheal (IT). Group 2 (n=6; sentinel) and Group 3 (n=3; mock control) were housed in a separate room. At 1-day post challenge (DPC), pigs in Group 2 were co-mingled with Group 1. Group 3 remained in separate housing. No evidence of infection or immune-response was detected in collected samples.