Safety of Recombinant VSV–Ebola Virus Vaccine Vector in Pigs

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The ongoing Ebola outbreak in West Africa has resulted in fast-track development of vaccine candidates. We tested a vesicular stomatitis virus vector expressing Ebola virus glycoprotein for safety in pigs. Inoculation did not cause disease and vaccine virus shedding was minimal, which indicated that the vaccine virus does not pose a risk of dissemination in pigs.

The current Ebola virus (EBOV) outbreak in West Africa has shown the need for an effective vaccine against this virus. As a result, clinical trials to test several vaccine candidates have been expedited (1) in hopes of contributing to containment of the outbreak. One of these vaccine candidates is based on a recombinant vesiculovirus vector, species vesicular stomatitis Indiana virus (here designated and more commonly known as VSV) expressing the EBOV strain Mayinga glycoprotein (here designated rVSVΔG/EBOVGP; formerly designated VSVΔG/ZEBOVGP) (2–4). This vaccine was highly efficacious in preexposure and postexposure studies in nonhuman primates after a single injection (5). In addition, the vaccine has been shown to be safe in simian HIV–infected rhesus macaques (6) and was not neurovirulent after intrathalamic inoculation into macaques (7).

However, because VSV is a World Organisation for Animal Health–listed pathogen (8), concerns might arise with regard to spillover of the vaccine vector to livestock when this vaccine is used on a larger scale in humans. To evaluate the safety of rVSVΔG/EBOVGP in a relevant livestock species, we inoculated pigs with this vaccine and compared clinical signs and virus replication with those of a recombinant wild-type VSV vector (rVSVwt) described previously (3).

The Study

All animal experiments were approved by the Institutional Animal Care and Use Committee of the Rocky Mountain Laboratories and performed following the guidelines of the Association for Assessment and Accreditation of Laboratory Animal Care, International. Experiments were performed by certified staff in an Association for Assessment and Accreditation of Laboratory Animal Care AAALAC–approved facility, following the guidelines and basic principles in the US Public Health Service Policy on Humane Care and Use of Laboratory Animals and the Guide for Care and Use of Laboratory Animals.

Four-week old pigs (Yorkshire cross) were obtained from the Washington State University College of Veterinary Medicine (Pullman, WA, USA). One group of 5 pigs and 1 group of 6 pigs were inoculated with rVSVwt and rVSVΔG/EBOVGP, respectively, as controls; 2 animals were mock inoculated with culture medium (Dulbecco modified Eagle medium). Animals were inoculated with 106 PFUs of either virus in a 100-μL volume, or an equal volume of Dulbecco modified Eagle medium by intradermal injection in the apex of the snout (9).

At regular intervals after inoculation, clinical examinations were performed to determine the health status of the animals and to collect nasal, throat, and rectal swab samples for virologic analysis; blood was collected to determine the humoral immune response. Three animals inoculated with rVSVwt and rVSVΔG/EBOVGP were euthanized at 3 days postinoculation (dpi) as per protocol; the remaining animals were euthanized at 21 dpi.

Inoculation of pigs with rVSVwt and rVSVΔG/EBOVGP did not result in obvious signs of disease (Table), changes in body temperature, or a decrease in weight gain compared with mock-inoculated controls. A nose lesion developed at 4 dpi at the injection site in 1 animal inoculated with rVSVwt, but this lesion healed by 9 dpi. Swab specimens collected from the lesion site on 5, 6, 7, 8, and 10 dpi were negative by virus titration. Nose, throat, and rectal swab specimens were collected at 1, 3, 6, 10, 14, and 21 dpi; a nose swab specimen collected at 3 dpi from a pig inoculated with rVSVΔG/EBOVGP was the only specimen in which virus could be detected (virus titer 100.83 50% tissue culture infectious dose [TCID50]/mL) (Table).

Three animals in each group were euthanized at 3 dpi. Tissue samples from lip, tongue, snout, footpad, coronary

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Table. Findings for pigs inoculated with rVSVwt and rVSV∆G/EBOVGP*

| Inoculum                      | Clinical signs | VSV lesions | Virus shedding from | Virus replication in tissues | Seroconversion at 21 dpi |
|-------------------------------|----------------|-------------|---------------------|------------------------------|-------------------------|
| Mock (control)                | ND             | ND          | ND                  | ND                           | ND                      |
| rVSVwt                        | ND             | 1/5†        | Nose, Throat        | ND                           | ND                      |
| rVSV∆G/EBOVGP                 | ND             | 1/6§        | Rectum, Viremia     | 2/3                          | 2/3                     |

†Virus positive in virus titration in 2 of 3 animals at 3 dpi.
§One swab collected from 1 animal positive at 3 dpi.
¶Snout positive in virus titration in 2 of 3 animals at 3 dpi.
‡Snout positive in 1 of 3 animals at 3 dpi; inguinal lymph node positive in 1 of 3 animals at 3 dpi.

*VSVwt, recombinant wild-type vesicular stomatitis virus; rVSV∆G/EBOVGP, recombinant VSV expressing Ebola virus strain Mayinga glycoprotein; VSV-G, VSV glycoprotein; dpi, day postinoculation; ND, not detected.

Because a high dose of the vaccine was directly injected intradermally into the snouts of the animals in this study and yet did not cause disease, it is unlikely that vaccination of humans with the rVSVΔG/EBOVGP vector would result in a productive infection with clinical disease in domestic pigs during a spillover event. Moreover, even if this spillover were to occur, the near absence of virus shedding in the rVSVΔG/EBOVGP–infected animals suggests that spillover would not result in maintenance of rVSVΔG/EBOVGP within a pig herd. This study provides data to support the safety of the live-attenuated VSVΔG/EBOVGP vaccine in a relevant livestock species. Should exposure/infection of pigs occur during a vaccination trial in humans, it is highly unlikely that signs of disease would develop in pigs or that the vaccine virus would be disseminated by interspecies or intraspecies transmission.

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References

1. Arie S. Trial of Ebola virus vaccine is due to start next week. BMJ. 2014;349:g5562. http://dx.doi.org/10.1136/bmj.g5562
2. Garbutt M, Liesbcher R, Wahl-Jensen V, Jones S, Moller P, Wagner R, et al. Properties of replication-competent vesicular stomatitis virus vectors expressing glycoproteins of filoviruses and arenaviruses. J Virol. 2004;78:5458–65. http://dx.doi.org/10.1128/JVI.78.10.5458-5465.2004
3. Lawson ND, Stillman EA, Whitt MA, Rose JK. Recombinant vesicular stomatitis viruses from DNA. Proc Natl Acad Sci U S A. 1995;92:4477–81. http://dx.doi.org/10.1073/pnas.92.10.4477
4. Jones SM, Feldmann H, Stroher U, Geisbert JB, Fernando L, Grolla A, et al. Live attenuated recombinant vaccine protects...
nonhuman primates against Ebola and Marburg viruses.
Nat Med. 2005;11:786–90. http://dx.doi.org/10.1038/nm1258
5. Geisbert TW, Feldmann H. Recombinant vesicular stomatitis virus–
based vaccines against Ebola and Marburg virus infections.
J Infect Dis. 2011;204(Suppl 3):S1075–81. http://dx.doi.
org/10.1093/infdis/jir349
6. Geisbert TW, Daddario-Dicaprio KM, Lewis MG, Geisbert JB,
Grolla A, Leung A, et al. Vesicular stomatitis virus–based Ebola
vaccine is well-tolerated and protects immunocompromised
nonhuman primates. PLoS Pathog. 2008;4:e1000225. http://dx.doi.
org/10.1371/journal.ppat.1000225
7. Mire CE, Miller AD, Carville A, Westmoreland SV, Geisbert JB,
Mansfield KG, et al. Recombinant vesicular stomatitis virus
vaccine vectors expressing filovirus glycoproteins lack
neurovirulence in nonhuman primates. PLoS Negl Trop Dis.
2012;6:e1567. Epub 2012 Mar 20.
8. World Organisation for Animal Health (OIE). OIE-listed diseases,
infections and infestations in force in 2014 [cited 2015 Jan 20].
http://www.oie.int/en/animal-health-in-the-world/oie-listed-
diseases-2014/
9. Stallknecht DE, Greer JB, Murphy MD, Mead DG, Howerth EW.
Effect of strain and serotype of vesicular stomatitis virus on viral
shedding, vesicular lesion development, and contact transmission
in pigs. Am J Vet Res. 2004;65:1233–9. http://dx.doi.org/10.2460/
ajvr.2004.65.1233
10. Marzi A, Ebihara H, Callison J, Groseth A, Williams KJ,
Geisbert TW, et al. Vesicular stomatitis virus–based Ebola
vaccines with improved cross-protective efficacy. J Infect Dis.
2011;204(Suppl 3):S1066–74. http://dx.doi.org/10.1093/
infdis/jir348
11. Nakayama E, Yokoyama A, Miyamoto H, Igarashi M, Kishida N,
Matsumo K, et al. Enzyme-linked immunosorbent assay for the
detection of filovirus species-specific antibodies. Clin Vaccine Im-
munol. 2010;17:1723–8. http://dx.doi.org/10.1128/CVI.00170-10
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