

Reference Summary for Ebola Therapeutics and Vaccines

This summary is compiled by the Infectious Disease Clinical Research Program (IDCRP) at the Uniformed Services University (USU) for the Armed Forces Infectious Disease Society (AFIDS). This summary was initially built from the 5 November 2014 World Health Organization (WHO) Paper on Potential Ebola Therapies and Vaccines.

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- Ver. 4: MAR 9, 2015 updates

THERAPEUTICS

1. ANTIBODY THERAPIES

▪ Convalescent Plasma

a. Human

- Sadek RF, Khan AS, Stevens G, Peters CJ, Ksiazek TG. Ebola hemorrhagic fever, Democratic Republic of the Congo, 1995: determinants of survival. *J Infect Dis.* 1999 Feb;179 Suppl 1:S24-7. **Follow-up to Mupapa et al. 1999**
http://jid.oxfordjournals.org/content/179/Supplement_1/S24.short
- Mupapa K, Massamba M, Kibadi K, et al. Treatment of Ebola hemorrhagic fever with blood transfusions from convalescent patients. International Scientific and Technical Committee. *J Infect Dis.* 1999 Feb;179 Suppl 1:S18-23.
http://jid.oxfordjournals.org/content/179/Supplement_1/S18.full
- Emond RT, Evans B, Bowen ET, Lloyd G. A case of Ebola virus infection. *Br Med J.* 1977 Aug 27;2(6086):541-4.
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1631428/pdf/brmedj00478-0011.pdf>

b. Non-Human Primates

- Jahrling PB, Geisbert JB, Swearingen JR, Larsen T, Geisbert TW. Ebola hemorrhagic fever: evaluation of passive immunotherapy in nonhuman primates. *J Infect Dis* 196(Suppl 2):S400-3, 2007 (**Negative results**)
http://jid.oxfordjournals.org/content/196/Supplement_2/S400.long

c. Small Animals

d. Convalescent Plasma Reviews and Reports

- Kreil, TR. Treatment of Ebola Virus Infection with Antibodies from Reconvalescent Donors. *Emerg Infect Dis.* 2015 Mar;21(3):521-3.
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4344290/>
- Gutfraind A, Meyers LA. Evaluating large-scale blood transfusion therapy for the current Ebola epidemic in Liberia. *J Infect Dis.* 2015 Jan 29. pii: jiv042. [Epub ahead of print]
<http://jid.oxfordjournals.org/content/early/2015/02/17/infdis.jiv042.long>
- Burnouf T, Seghatchian J. Ebola virus convalescent blood products: Where we are now and where we may need to go. *Transfus Apher Sci.* 2014 Oct;51(2):120-5.
- WHO Blood Regulators Network (BRN) **Position Paper** on Collection and Use of Convalescent Plasma or Serum as an Element in Filovirus Outbreak Response. 14 August 2014
http://www.who.int/bloodproducts/brn/brn_positionpaperconvplasmafiloviruses_finalweb14august2014.pdf

▪ Immunoglobulin

a. Human

- Kudoyarova-Zubavichene NM, Sergeev NN, Chepurnov AA, Netesov SV. Preparation and use of hyperimmune serum for prophylaxis and therapy of ebola virus infection. *J Infect Dis* 179 (Supplement 1):S218-S223, 1999

http://jid.oxfordjournals.org/content/179/Supplement_1/S218.full

b. Non-Human Primates

- Dye JM, Herbert AS, Kuehne AI, et al. 2012. Postexposure antibody prophylaxis protects nonhuman primates from filovirus disease. *Proc Natl Acad Sci U S A* 109:5034-5039. <http://www.pnas.org/content/109/13/5034.full.pdf>
- Jahrling PB, Geisbert J, Swearingen JR, et al. Passive immunization of Ebola virus-infected cynomolgus monkeys with immunoglobulin from hyperimmune horses. *Arch Virol* 11(Suppl):135-40, 1996 **(Negative results)**
- Borisevich IV, Mikhaïlov VV, Krasnianskiï VP, et al. Development and study of the properties of immunoglobulin against Ebola fever. *Vopr Virusol* 40(6):270-3, 1995 (only abstract available, article in Russian)

c. Small Animals

d. Immunoglobulin Reviews and Reports

- Chippaux JP, Boyer LV, Alagón A. Post-exposure treatment of Ebola virus using passive immunotherapy: proposal for a new strategy. *J Venom Anim Toxins Incl Trop Dis*. 2015 Feb 15;21:3. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4336475/>

▪ **Monoclonal Antibodies**

a. Human

b. Non-Human Primates

- Qiu X, Wong G, Audet J, et al. Reversion of advanced Ebola virus disease in nonhuman primates with **ZMapp**. *Nature*. 2014 Oct 2;514(7520):47-53.
- Qiu X, Audet J, Wong G, et al. Sustained protection against Ebola virus infection following treatment of infected nonhuman primates with **ZMAb**. *Sci Rep*. 2013 Nov 28;3:3365. <http://www.nature.com/srep/2013/131128/srep03365/full/srep03365.html>
- Pettitt J, Zeitlin L, Kim DH, et al. Therapeutic Intervention of Ebola Virus Infection in Rhesus Macaques with the **MB-003** Monoclonal Antibody Cocktail. *Science Transl Med* 5(199):199ra113, 2013 <http://stm.sciencemag.org/content/5/199/199ra113.full>
- Qiu X, Audet J, Wong G, et al. Successful treatment of Ebola virus-infected cynomolgus macaques with monoclonal antibodies. *Sci Transl Med*. 2012 Jun 13;4(138):138ra81. **ZMAb** <http://stm.sciencemag.org/content/4/138/138ra81.long>
- Olinger GG Jr, Pettitt J, Kim D, et al. Delayed treatment of Ebola virus infection with plant-derived monoclonal antibodies provides protection in rhesus macaques. *Proc. Natl. Acad. Sci. U.S.A.* 109: 18030–18035, 2012. **MB-003** <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3497800/>
- Oswald WB, Geisbert TW, Davis KJ, et al. Neutralizing antibody fails to impact the course of Ebola virus infection in monkeys. *PLoS Pathog*. 2007 Jan;3(1):e9. **KZ52 (Negative results)** <http://www.plospathogens.org/article/info%3Adoi%2F10.1371%2Fjournal.ppat.0030009#ppat-0030009-g002>

c. Small Animals

- Parren PW, Geisbert TW, Maruyama T, Jahrling PB, Burton DR. Pre- and postexposure prophylaxis of Ebola virus infection in an animal model by passive transfer of a neutralizing human antibody. *J Virol* 2002;76:6408-12. **KZ52** <http://jvi.asm.org/content/76/12/6408.full>

▪ **Antibody Therapy Reviews and Reports**

- Ponomarenko J, Vaughan K, Sette A, Maurer-Stroh S. Conservancy of mAb Epitopes in Ebolavirus Glycoproteins of Previous and 2014 Outbreaks. *PLoS Curr*. 2014 Nov 3;6. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4234462/>
- Qiu X, Kobinger GP. Antibody therapy for Ebola: Is the tide turning around? *Hum Vaccin Immunother*. 2014 Apr;10(4):964-7.

2. ANTI-VIRALS

- **Polymerase inhibitors**
 - a. **Human**
 - b. **Non-Human Primates**
 - Warren TK, Wells J, Panchal RG, et al. Protection against filovirus diseases by a novel broad-spectrum nucleoside analogue **BCX4430**. *Nature*. 2014 Apr 17;508(7496):402-5.
 - c. **Small Animals**
 - Smither SJ, Eastaugh LS, Steward JA, et al. Post-exposure efficacy of Oral **T-705 (Favipiravir)** against inhalational Ebola virus infection in a mouse model. *Antiviral Research* 104:153–155, 2014
 - Oestereich L, Lüdtke A, Wurr S, et al. Successful treatment of advanced Ebola virus infection with **T-705 (favipiravir)** in a small animal model. *Antiviral Research* 105:17–21, 2014
<http://www.sciencedirect.com/science/article/pii/S0166354214000576>
 - d. **Polymerase Inhibitor Reviews and Reports**
 - Bouazza N, Treluyer JM, Foissac F, et al. Favipiravir for children with Ebola. *Lancet*. 2015 Feb 14;385(9968):603-4.
<http://www.sciencedirect.com/science/article/pii/S014067361560232X>
 - Nagata T, Lefor AK, Hasegawa M, Ishii M. Favipiravir: A New Medication for the Ebola Virus Disease Pandemic. *Disaster Med Public Health Prep*. 2014 Dec 29:1-3.
 - Furuta Y, Gowen BB, Takahashi K, et al. **Favipiravir (T-705)**, a novel viral RNA polymerase inhibitor. *Antiviral Res*. 2013 Nov;100(2):446-54.
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3880838/>
- **Lipid nanoparticle/small interfering RNA (LNP/siRNA)**
 - a. **Human**
 - Tekmira. TKM-Ebola in development <http://www.tekmira.com/pipeline/tkm-ebola.php>
 - b. **Non-Human Primates**
 - Thi EP, Mire CE, Ursic-Bedoya R, et al. Marburg virus infection in nonhuman primates: Therapeutic treatment by lipid-encapsulated siRNA. *Sci Transl Med*. 2014 Aug 20;6(250):250ra116. **NP-718m**
<http://stm.sciencemag.org/content/6/250/250ra116.short>
 - Geisbert TW, Lee AC, Robbins M, et al. Postexposure protection of non-human primates against a lethal Ebola virus challenge with RNA interference: a proof-of-concept study. *Lancet* 375:1896-1905, 2010
<http://download.thelancet.com/pdfs/journals/lancet/PIIS0140673610603571.pdf?id=gaa79G73ifyidcewDbMMu>
 - c. **Small Animals**
 - Geisbert TW, Hensley LE, Kagan E, et al. Postexposure protection of guinea pigs against a lethal ebola virus challenge is conferred by RNA interference. *J Infect Dis* 193:1650-1657, 2007 <http://jid.oxfordjournals.org/content/193/12/1650.long>
- **Anti-sense phosphorodiamidate morpholino oligomers (PMOs)**
 - a. **Human**
 - Sarepta Therapeutics in development <http://www.sarepta.com/pipeline/avi-7288-marburg>
 - Heald AE, Iversen PL, Saoud JB, et al. Safety and Pharmacokinetic Profiles of Phosphorodiamidate Morpholino Oligomers with Activity against Ebola Virus and Marburg Virus: Results of Two Single-Ascending-Dose Studies. *Antimicrob Agents Chemother*. 2014 Nov;58(11):6639-47.
<http://aac.asm.org/content/58/11/6639.full.pdf+html>
 - b. **Non-Human Primates**

- Warren TK, Whitehouse CA, Wells J, et al. A Single Phosphorodiamidate Morpholino Oligomer Targeting VP24 Protects Rhesus Monkeys against Lethal Ebola Virus Infection. *MBio*. 2015 Feb 10;6(1). <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4337572/>
 - Warren TK, Warfield KL, Wells J, et al. Advanced antisense therapies for postexposure protection against lethal filovirus infections. *Nat Med*. 2010 Sep;16(9):991-4.
 - Warfield KL, Swenson DL, Olinger GG, et al. Gene-specific countermeasures against Ebola virus based on antisense phosphorodiamidate morpholino oligomers. *PLoS Pathog*. 2006 Jan;2(1):e1. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1326218/>
 - c. **Small Animals**
 - Iversen PL, Warren TK, Wells JB, et al. Discovery and Early Development of **AVI-7537** and **AVI-7288** for the Treatment of Ebola Virus and Marburg Virus Infections. *Viruses*. 2012 Nov 6;4(11):2806-30. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3509674/>
 - **Selective Estrogen Receptor Modulators (SERMS)**
 - a. **Human**
 - b. **Non-Human Primates**
 - c. **Small Animals**
 - Johansen LM, Brannan JM, Delos SE, et al. FDA-Approved Selective Estrogen Receptor Modulators Inhibit Ebola Virus Infection. *Sci Transl Med* 5(190): 190ra79, 2013 <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3955358/>
 - **Anti-virals Reviews and Reports**
 - Hensley LE, Dyall J, Olinger GG Jr, Jahrling PB. Lack of Effect of Lamivudine on Ebola Virus Replication. *Emerg Infect Dis*. 2015 Mar;21(3):550-2. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4344292/>
 - Litterman N, Lipinski C, Ekins S. Small molecules with antiviral activity against the Ebola virus. *F1000Res*. 2015 Feb 9;4:38. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4335594/>
 - Picazo E, Giordanetto F. Small molecule inhibitors of ebola virus infection. *Drug Discov Today*. 2014 Dec 19.
 - Florescu DF, Keck MA. Development of **CMX001 (Brincidofovir)** for the treatment of serious diseases or conditions caused by dsDNA viruses. *Expert Rev Anti Infect Ther*. 2014 Oct;12(10):1171-8.
 - Huggins JW. Prospects for treatment of viral hemorrhagic fevers with **ribavirin**, a broad-spectrum antiviral drug. *Rev Infect Dis* 11 Suppl 4:S750-61, 1989
3. **ANTI-INFLAMMATORIES**
- **Interferons**
 - a. **Human**
 - b. **Non-Human Primates**
 - Smith LM, Hensley LE, Geisbert TW, et al. **Interferon- β** Therapy Prolongs Survival in Rhesus Macaque Models of Ebola and Marburg. *J Infect Dis*. 2013 Jul 15;208(2):310-8 <http://jid.oxfordjournals.org/content/208/2/310.long>
 - c. **Small Animals**
4. **ANTI-COAGULANTS**
- a. **Human**
 - b. **Non-Human Primates**
 - Geisbert TW, Hensley LE, Jahrling PB, et al. Treatment of Ebola virus infection with a recombinant inhibitor of factor VIIa/tissue factor: a study in rhesus monkeys. *Lancet* 362:1953-1958, 2003 (**rhAPC [Xigris; Eli Lilly]**) [http://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(03\)15012-X/fulltext](http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(03)15012-X/fulltext)
 - c. **Small Animals**
5. **SEPSIS-RELATED THERAPIES**

a. Human

b. Non-Human Primates

- Hensley LE, Stevens EL, Yan SB, et al. Recombinant human activated protein C for the postexposure treatment of Ebola hemorrhagic fever. *J Infect Dis* 196 Suppl 2:S390-9, 2007 (rNAPc2) http://jid.oxfordjournals.org/content/196/Supplement_2/S390.long

c. Small Animals

6. COMBINATION THERAPIES

▪ **Interferons with Antibodies**

a. Human

b. Non-Human Primates

- Qiu X, Wong G, Fernando L, et al. mAbs and Ad-vectored IFN- α therapy rescue Ebola-infected nonhuman primates when administered after the detection of viremia and symptoms. *Sci Transl Med*. 5(207):207ra143, 2013. <http://stm.sciencemag.org/content/5/207/207ra143.long>
- Jahrling PB, Geisbert TW, Geisbert JB, et al. Evaluation of immune globulin and recombinant interferon-alpha2b for treatment of experimental Ebola virus infections. *J Infect Dis* 179 Suppl 1:S224-34, 1999 (**Negative results**) http://jid.oxfordjournals.org/content/179/Supplement_1/S224.long

c. Small Animals

- Qiu X, Wong G, Fernando L, et al. Monoclonal antibodies combined with adenovirus-vectored interferon significantly extend the treatment window in Ebola virus-infected guinea pigs. *J Virol* 87(13):7754-7, 2013 <http://jvi.asm.org/content/87/13/7754.long>
- Richardson JS, Wong G, Pillet S, et al. Evaluation of different strategies for post exposure treatment of ebola virus infection in rodents. *J Bioterr Biodef* S1:007, 2011 <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3509938/>
- Ignatyev G, Steinkasserer A, Streltsova M, et al. Experimental study on the possibility of treatment of some haemorrhagic fevers. *J Biotechnol*. 2000 Sep 29;83(1-2):67-76.

7. EXTRACORPOREAL ELIMINATION

a. Human

- Büttner S, Koch B, Dolnik O, et al. Extracorporeal virus elimination for the treatment of severe ebola virus disease - first experience with lectin affinity plasmapheresis. *Blood Purif*. 2014;38(3-4):286-91. Epub 2015 Feb 11. <http://www.karger.com/Article/FullText/375229>

b. Non-Human Primates

c. Small Animals

8. THERAPEUTICS REVIEWS AND REPORTS

- Anderson G, Maes M, Markus RP, Rodriguez M, et al. Ebola virus: Melatonin as a readily available treatment option. *J Med Virol*. 2015 Apr;87(4):537-43. <http://onlinelibrary.wiley.com/doi/10.1002/jmv.24130/abstract>
- Choi WY, Hong KJ, Hong JE, Lee WJ. Progress of vaccine and drug development for Ebola preparedness. *Clin Exp Vaccine Res*. 2015 Jan;4(1):11-6. [Epub 2015 Jan 30]. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4313103/>
- Kilgore PE, Grabenstein JD, Salim AM, Rybak M. Treatment of ebola virus disease. *Pharmacotherapy*. 2015 Jan;35(1):43-53. <http://onlinelibrary.wiley.com/doi/10.1002/phar.1545/abstract>
- Ekins S, Freundlich JS, Coffee M. A common feature pharmacophore for FDA-approved drugs inhibiting the Ebola virus. Version 2. *F1000Res*. 2014 Nov 14 [revised 2014 Dec 12]. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4304229/>
- Masters A, R S, Pandi-Perumal, Seixas A, Jean-Louis G, McFarlane SI. Melatonin, the Hormone of Darkness: From Sleep Promotion to Ebola Treatment. *Brain Disord Ther*. 2014;4(1). <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4334454/>

- Lai KY, Ng WY, Cheng FF. Human Ebola virus infection in West Africa: a review of available therapeutic agents that target different steps of the life cycle of Ebola virus. *Infect Dis Poverty*. 2014 Nov 28;3:43.
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4334593/>

VACCINES

1. DNA VACCINES

a. Human

- Kibuuka H, Berkowitz NM, Millard M, et al. Safety and immunogenicity of Ebola virus and Marburg virus glycoprotein DNA vaccines assessed separately and concomitantly in healthy Ugandan adults: a phase 1b, randomised, double-blind, placebo-controlled clinical trial. *Lancet*. 2014 Dec 22.
[http://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(14\)62385-0/abstract](http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(14)62385-0/abstract)
- Sarwar UN, Costner P, Enama ME, et al. Safety and Immunogenicity of DNA Vaccines Encoding Ebolavirus and Marburgvirus Wild-Type Glycoproteins in a Phase I Clinical Trial. *J Infect Dis*. 2014 Sep 14. pii: jiu511.
<http://jid.oxfordjournals.org/content/early/2014/11/12/infdis.jiu511.long>
- Martin JE, Sullivan NJ, Enama ME, et al. A DNA vaccine for Ebola virus is safe and immunogenic in a phase I clinical trial. *Clin Vaccine Immunol* 2006;13:1267-77.
http://cvi.asm.org/content/13/11/1267.abstract?ijkey=695a262190fea390ee8ee4b5914be7f020dffa86&keytype2=tf_ipsecsha

b. Non-Human Primates

c. Small Animals

2. ADENOVIRAL VECTORS

a. Human

- Ledgerwood JE, DeZure AD, Stanley DA, et al. Chimpanzee Adenovirus Vector Ebola Vaccine - Preliminary Report. *N Engl J Med*. 2014 Nov 26. [Epub ahead of print]
<http://www.nejm.org/doi/full/10.1056/NEJMoa1410863>

b. Non-Human Primates

- Rampling T, Ewer K, Bowyer G, et al. A Monovalent Chimpanzee Adenovirus Ebola Vaccine - Preliminary Report. *N Engl J Med*. 2015 Jan 28. [Epub ahead of print].
<http://www.nejm.org/doi/full/10.1056/NEJMoa1411627>
- Choi JH, Jonsson-Schmunk K, Qiu X, et al. A Single Dose Respiratory Recombinant Adenovirus-Based Vaccine Provides Long-Term Protection for Non-Human Primates from Lethal Ebola Infection. *Mol Pharm*. 2014 Nov 1. **Ad-CAGoptZGP**
<http://pubs.acs.org/doi/abs/10.1021/mp500646d>
- Stanley DA, Honko AN, Asiedu C, et al. Chimpanzee adenovirus vaccine generates acute and durable protective immunity against ebolavirus challenge. *Nat Med*. 2014 Oct;20(10):1126-9
- Sullivan NJ, Geisbert TW, Geisbert JB, et al. Immune protection of nonhuman primates against Ebola virus with single low-dose adenovirus vectors encoding modified GPs. *PLoS Med*. 2006 Jun;3(6):e177.
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1459482/>
- Sullivan NJ, Geisbert TW, Geisbert JB, et al. Accelerated vaccination for Ebola virus haemorrhagic fever in non-human primates. *Nature*. 2003 Aug 7;424(6949):681-4. **ADV-GP/NP**

c. Small Animals

- Wong G, Richardson JS, Cutts T, Qiu X, Kobinger GP. Intranasal immunization with an adenovirus vaccine protects guinea pigs from Ebola virus transmission by infected animals. *Antiviral Res*. 2015 Jan 14;116C:17-19.
<http://www.sciencedirect.com/science/article/pii/S0166354215000029>
- Choi JH, Schafer SC, Freiberg AN, Croyle MA. Bolstering Components of the Immune Response Compromised by Prior Exposure to Adenovirus: Guided Formulation Development for a Nasal Ebola Vaccine. *Mol Pharm*. 2014 Dec 30. [Epub ahead of print]

3. VESICULAR STOMATITIS VIRUS VECTORS

a. Human

- Lai L, Davey R, Beck A, et al. Emergency Postexposure Vaccination With Vesicular Stomatitis Virus-Vectored Ebola Vaccine After Needlestick. *JAMA*. 2015 Mar 5. [Epub ahead of print] <http://jama.jamanetwork.com/article.aspx?articleid=2195001>
- Günther S, Feldmann H, Geisbert TW, et al. Management of Accidental Exposure to Ebola Virus in the Biosafety Level 4 Laboratory, Hamburg, Germany. *J Infect Dis*. 2011 Nov;204 Suppl 3:S785-90. http://jid.oxfordjournals.org/content/204/suppl_3/S785.long

b. Non-Human Primates

- Barrenas F, Green RR, Thomas MJ, et al. Next generation sequencing reveals a controlled immune response to Zaire Ebola virus challenge in cynomolgus macaques immunized with VSVDeltaG/EBOVgp. *Clin Vaccine Immunol*. 2015 Mar;22(3):354-6. <http://cvi.asm.org/content/22/3/354.long>
- Marzi A, Feldmann F, Geisbert TW, Feldmann H, Safronetz D. Vesicular Stomatitis Virus-Based Vaccines against Lassa and Ebola Viruses. *Emerg Infect Dis*. 2015 Feb;21(2):305-7. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4313664/>
- Marzi A, Engelmann F, Feldmann F, et al. Antibodies are necessary for rVSV/ZEBOV-GP-mediated protection against lethal Ebola virus challenge in nonhuman primates. *Proc Natl Acad Sci U S A*. 2013 Jan 29;110(5):1893-8. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3562844/>
- Mire CE, Miller AD, Carville A, et al. Recombinant Vesicular Stomatitis Virus Vaccine Vectors Expressing Filovirus Glycoproteins Lack Neurovirulence in Nonhuman Primates. *PLoS Negl Trop Dis*. 2012;6(3) <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3308941/>
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- Feldmann H, Jones SM, Daddario-DiCaprio KM, et al. Effective post-exposure treatment of Ebola infection. *PLoS Pathog*. 2007 Jan;3(1):e2. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1779298/>
- Jones SM, Feldmann H, Ströher U, et al. Live attenuated recombinant vaccine protects nonhuman primates against Ebola and Marburg viruses. *Nat Med*. 2005 Jul;11(7):786-90.

c. Small Animals

- Williams KJ, Qiu X, Fernando L, Jones SM, Alimonti JB. VSVDeltaG/EBOV GP-Induced Innate Protection Enhances Natural Killer Cell Activity to Increase Survival in a Lethal Mouse Adapted Ebola Virus Infection. *Viral Immunol*. 2015 Feb;28(1):51-61.
- Wong G, Audet J, Fernando L, et al. Immunization with vesicular stomatitis virus vaccine expressing the Ebola glycoprotein provides sustained long-term protection in rodents. *Vaccine*. 2014 Sep 29;32(43):5722-9.

4. VIRUS-LIKE PARTICLES

a. Human

b. Non-Human Primates

- Pyankov OV, Bodnev SA, Pyankova OG, et al. A Kunjin Replicon Virus-like Particle Vaccine Provides Protection Against Ebola Virus Infection in Nonhuman Primates. *J Infect Dis*. 2015 Mar 2. [Epub ahead of print]

c. Small Animals

- Ayithan N, Bradfute SB, Anthony SM, et al. Virus-Like Particles Activate Type I Interferon Pathways to Facilitate Post-Exposure Protection against Ebola Virus Infection. *PLoS One*.

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<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4342244/>

5. VACCINE REVIEWS AND REPORTS

- Ye L, Yang C. Development of vaccines for prevention of Ebola virus infection. *Microbes Infect.* 2014 Dec 16.
- Fisman D, Tuite A. Projected impact of vaccination timing and dose availability on the course of the 2014 west african ebola epidemic. *PLoS Curr.* 2014 Nov 21;6.
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4318922/>
- Hampton T. Largest-ever outbreak of Ebola virus disease thrusts experimental therapies, vaccines into spotlight. *JAMA.* 2014 Sep 10;312(10):987-9.
<http://jama.jamanetwork.com/article.aspx?articleid=1900785>
- Arie S. Trial of Ebola virus vaccine is due to start next week. *BMJ.* 2014 Sep 9;349:g5562.
- Galvani AP, Ndeffo-Mbah ML, Wenzel N, Childs JE. Ebola Vaccination: If Not Now, When? *Ann Intern Med.* 2014 Aug 21
<http://annals.org/article.aspx?articleid=1899514>
- Marzi A, Feldmann H. Ebola virus vaccines: an overview of current approaches. *Expert Rev Vaccines.* 2014 Apr;13(4):521-31.

EPIDEMIOLOGY AND CLINICAL CHARACTERISTICS OF EVD (2014 Outbreak)

- Koonin LM, Jamieson DJ, Jernigan JA, et al. Systems for Rapidly Detecting and Treating Persons with Ebola Virus Disease - United States. *MMWR Morb Mortal Wkly Rep.* 2015 Mar 6;64(8):222-5.
<http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6408a5.htm>
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<http://www.nature.com/srep/2015/150304/srep08751/full/srep08751.html>
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<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4344293/>
- Rainisch G, Shankar M, Wellman M, Merlin T, Meltzer MI. Regional spread of ebola virus, west Africa, 2014. *Emerg Infect Dis.* 2015 Mar;21(3):444-7.
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