

ENCEPHALOMYOCARDITIS VIRUS

Aetiology Epidemiology Diagnosis Prevention and Control
Potential Impacts of Disease Agent Beyond Clinical Illness References

AETIOLOGY

Classification of the causative agent

Encephalomyocarditis virus (EMCV) is the causative agent of encephalomyocarditis (EMC) infection in swine and other mammals. It is a non-enveloped, positive-sense, single-stranded RNA virus that is part of the *Cardiovirus* genus and *Picornaviridae* family. The two serotypes of this virus are EMCV-1 and EMCV-2; the former is more prevalent and causes known pathology in its hosts. Most outbreaks occur in captivity. Two strains of EMCV-1 are found in swine: type A causes reproductive disease, and type B results in heart failure.

Resistance to physical and chemical action

Temperature: Inactivated at 60°C after 30 minutes
pH: Stable at pH 3-8
Chemicals/Disinfectants: Iodine, aldehyde, phenol-based disinfectants, mercuric chloride, water with 0.5 ppm chlorine
Survival: Inactivated at humidity levels <50%

EPIDEMIOLOGY

Hosts

Several mammalian species are susceptible to infection. The following is not an exhaustive list.

- Domestic swine (*Sus scrofa domesticus*)
- Wild boars (*Sus scrofa*)
- African elephants (*Loxodonta africana*)
- Two-toed sloths (*Choloepus didactylus*)
- Llamas (*Lama glama*)
- Goodfellow's tree-kangaroo (*Dendrolagus goodfellowi*)
- Pygmy hippopotamuses (*Choeropsis liberiensis*)
- Black rhinoceroses (*Diceros bicornis*)
- Lions (*Panthera leo*)
- Nonhuman primates
 - Orangutans (*Pongo pygmaeus*)
 - Chimpanzees (*Pan troglodytes*)
 - Gibbon (*Hylobates* spp.)
 - Lemurs
 - Ring-tailed lemurs (*Lemur catta*)
 - Black lemurs (*Eulemur macaco*)
 - White-fronted lemurs (*Eulemur albifrons*)
 - Red ruffed lemurs (*Varecia variegata rubra*)
 - Barbary macaque (*Macaca sylvanus*)
 - Common marmoset (*Callithrix jacchus*)
 - Squirrel monkey (*Saimiri sciureus*)
 - Mandrill (*Mandrillus sphinx*)
- Rodents
 - Rats are the reservoir species
 - Black rats (*Rattus rattus*)
 - Norwegian rats (*Rattus norvegicus*)

- Cotton rats (*Sigmodon hispidus*)
- Mice (*Mus domesticus*)

Transmission

- Consumption of food and water contaminated with rodent urine or feces
- Ingestion of rats or mice infected with EMCV
- Transplacental (vertical) transmission in swine
- Direct transmission between pigs has not been documented

Sources

- Infected rodents
- Food and water contaminated with rodent excreta

Occurrence

EMCV was first identified and isolated in 1945 from a gibbon in the state of Florida in the United States. The first documented instance of EMCV in pigs was 1958 in Panama. It is widespread throughout the world, particularly in South America, Australia, China, Europe, Canada, and the United States.

African elephants appear to be particularly susceptible to EMCV infection. There have been several outbreaks, both in captivity and the wild. From 1993-1994, an outbreak of EMCV occurred in a herd of elephants in Kruger National Park, South Africa that corresponded with an increase in the local rodent population.

Disease incidence among species in human care has been sporadically reported. Between 2006 and 2008 in an Italian zoo, eighteen nonhuman primates, including macaques, marmosets, and several species of lemur, died of EMCV. The outbreak was thought to be due to an increased rat population in the park. An Australian zoo experienced a series of EMCV-related deaths across several years (1987-1995) in several different mammals, including an African elephant, pygmy hippopotamus, Goodfellow's tree kangaroo, mandrill, ring-tailed lemur, and squirrel monkey.

Wild boars are considered potential reservoirs for the virus, though they may also present with signs of infection. From 2012-2015, an outbreak of EMCV occurred in several semi-captive wild boars in Henan province, China. In South Korea, EMCV was isolated from serum in about 7% of a population of wild boars experiencing reproductive failure.

EMCV is a zoonotic disease, therefore humans are susceptible to infection; the source of concern for transmission is swine. Most infections in humans are asymptomatic. Past serosurveys have detected EMCV in humans in Peru, Austria, and the Philippines.

For more recent, detailed information on the occurrence of this disease worldwide, see the OIE World Animal Health Information System - Wild (WAHIS-Wild) Interface [http://www.oie.int/wahis_2/public/wahidwild.php/Index].

DIAGNOSIS

Mortality may approach 100% in piglets aged 4 days to 24 weeks. Death occurs about 2-11 days after infection. Arthropods have been found carrying EMCV, though they have not been shown to transmit the virus, and rats can transmit the virus up to a month after initial infection.

EMCV travels to the tonsils, where it infects monocytes. These infected monocytes then spread to other organs, most notably the heart. It is not believed that EMCV is highly contagious.

The transmission of EMCV to animals is thought to occur mostly from rodents. For example, it is thought that most EMCV outbreaks in zoological parks have been caused by rats. Similarly, on swine operations, EMCV infection is also believed to be caused by rats due to the minimal evidence of horizontal transmission between pigs.

Clinical diagnosis

Signs of infection include anorexia, vomiting, dyspnoea, fever, and myocarditis. If death does not occur, pigs may develop chronic myocarditis. It can also cause reproductive disease in adult swine and sudden death in piglets. Reproductive abnormalities associated with EMCV-infected swine include abortion and mummified foetuses.

Rodents with EMCV generally present without clinical signs. Captive animals infected with EMCV develop myocarditis and may die secondary to cardiac failure. Many die suddenly without showing clinical signs; other possible signs include lethargy and depression. African elephants that have been experimentally infected with EMCV develop malaise, depression, and trunk swinging.

Lesions

- Pale, necrotic myocardium
 - Non-suppurative interstitial myocarditis
 - Mononuclear cellular infiltrates
- Necrotising pancreatitis
- Lymphadenopathy
- Necrotising tonsillitis
- Pulmonary oedema
- Hydrothorax
- Ascites
- Brain
 - Perivascular infiltration of mononuclear cells
 - Meningitis
 - Neuronal degeneration

Differential diagnoses

- Vitamin E/Selenium deficiency
- Septic myocardial infarction/myocarditis
- Swine abortion or other reproductive disease
 - Porcine Reproductive and Respiratory Syndrome (PRRS)
 - Porcine parvovirus (PPV)
 - Pseudorabies (Porcine herpesvirus 1)
 - Porcine circovirus type 2 (PCV2)
 - Porcine enterovirus
 - Brucellosis (*Brucella suis*)
 - Leptospirosis (*Leptospira interrogans* serovar Pomona)
 - Classical swine fever (hog cholera)
- Other mammals
 - Myocarditis
 - Ionophore toxicity
 - Cardiotoxic plant ingestion
 - Pericardial effusion, restrictive pericarditis

Laboratory diagnosis

Samples

For isolation of agent

- Heart
- Brain
- Spleen
- Kidney
- Liver
- Aborted foetus

Serological tests

- Serum

Procedures

Identification of the agent

- Reverse-transcriptase polymerase chain reaction (RT-PCR)
 - Another form of this, reverse-transcriptase loop-mediated isothermal amplification (RT-LAMP), is in development
- Fluorescent antibody test using anti-EMCV fluorescently-conjugated antibody
- Viral isolation using several different cell lines
 - Baby hamster kidney fibroblasts (BHK-21)
 - Mouse embryo
 - Chick embryo
 - Human cancer (HeLa) cell lines
 - African green monkey kidney (Vero)

Serological tests

- Antibody capture enzyme-linked immunosorbent assay (ELISA)
- Virus neutralization (VN)
- Immunofluorescent antibody assay (IFA)
- Agar-gel immunodiffusion (AGID)
- Haemagglutination-inhibition (HI)

PREVENTION AND CONTROL

Sanitary prophylaxis

- On swine farms and in zoos, minimize overcrowding, provide enrichment, proper environmental conditions (e.g., temperature), and ventilation to help maintain a low-stress environment
- Maintain low rodent populations through the use of rodenticides, baits, and traps as well as destruction of nearby rodent dwellings
- Ensure proper fencing, housing, or enclosures to prevent interaction with wild rodents and boars
- Sanitation and disinfection of captive enclosures
- Cover feed to prevent contamination with rodent excreta
- Incinerate EMCV-suspect carcasses

Medical prophylaxis

- Autogenous vaccines are often used in zoos
- A genetically engineered attenuated virus vaccine is available for use in pigs, non-human primates, and ungulates

POTENTIAL IMPACTS OF DISEASE AGENT BEYOND CLINICAL ILLNESS

Risks to public health

- EMCV has been found in human serosurveys. Infection may be asymptomatic but symptoms can include flu-like symptoms, vomiting, pleocytosis, delirium, and nuchal rigidity.
- No pig-to-human transmission has been documented, but there is concern that humans could obtain EMCV from pig donor xenografts. There is no evidence of viral transmission from rodents to humans.
- Hunters, swine farms workers, zookeepers, and veterinarians should utilize proper biosafety practices to minimize risk of infection.

Risks to agriculture

- If a swine herd is infected with EMCV, there will be production losses to the farm due to high mortality rates in piglets and chronic myocarditis in adults.

REFERENCES AND OTHER INFORMATION

- Canelli, E., Luppi, A., Lavazza, A., Lelli, Sozzi, E., Moreno, A. M., et al. (2010). Encephalomyocarditis virus infection in an Italian zoo. *Virology Journal*, 7(64), 1-7.
- Carocci, M. & Bakkali-Kassimi, L. (2012). The encephalomyocarditis virus. *Virulence*, 3(4), 351-367.
- Citino, S. B. (1995). *Encephalomyocarditis virus (EMCV) infectious disease leaflet* [Leaflet]. ResearchGate.
https://www.researchgate.net/publication/331962694_ENCEPHALOMYOCARDITIS_VIRUS_EMCV_Infectious_Disease_Leaflet
- Gaskin, J. M. (2013). Overview of encephalomyocarditis virus infection. *Merck Veterinary Manual*. Accessed 2020: <https://www.merckvetmanual.com/generalized-conditions/encephalomyocarditis-virus-infection/overview-of-encephalomyocarditis-virus-infection>
- Grobler, D. G., Raath, J. P., Braack, L. E. O., Keet, D. F., Gerdes, G. H., Barnard, B. J.H., et al. (1995). An outbreak of encephalomyocarditis-virus infection in free-ranging African elephants in the Kruger National Park. *Onderstepoort Journal of Veterinary Research*, 62, 97-108.
- Horak, S., Killoran, K., & Leedom Larson, K. R. (2016). Encephalomyocarditis virus. Swine Health Information Center for Food Security and Public Health. <http://www.cfsph.iastate.edu/pdf/shic-factsheet-encephalomyocarditis-virus>
- Jeoung, H., Lim, S., Kim, J., Cho, Y., Kim, Y. K., Song, J., et al. (2015). Serological prevalence of viral agents that induce reproductive failure in South Korean wild boar. *BMC Veterinary Research*, 11(78), 1-4.
- Liu, H., He, X., Song, X., Xu, L., Zhang, Y, Zhou, G., et al. (2016). Isolation and molecular and phylogenetic analyses of encephalomyocarditis virus from wild boar in central China. *Infection, Genetics, and Evolution*, 40, 67-72.
- Pedersen, L. G. (2018). Overview of commercial pig production systems and their main welfare challenges. In M. Špinková (Ed.), *Advances in Pig Welfare* (p. 18). Woodhead Publishing.
- Reddacliff, L. A., Kirkland, P. D., Hartley, W. J., & Reece, R. L. (1997). Encephalomyocarditis virus infections in an Australian zoo. *Journal of Zoo and Wildlife Medicine*, 28(2), 153-157.
- Tibary, A. (2015). Abortion in pigs. *Merck Veterinary Manual*. Accessed 2020: <https://www.merckvetmanual.com/reproductive-system/abortion-in-large-animals/abortion-in-pigs>

*

* *

The OIE will periodically update the OIE Technical Disease Cards. Please send relevant new references and proposed modifications to the OIE Science Department (scientific.dept@oie.int). Last updated 2020. Written by Samantha Gieger and Erin Furmaga with assistance from the USGS National Wildlife Health Center.