

FOOT AND MOUTH DISEASE

Aetiology Epidemiology Diagnosis Prevention and Control References

AETIOLOGY

Classification of the causative agent

A virus of the family Picornaviridae, genus *Aphthovirus*. Seven immunologically distinct serotypes: A, O, C, SAT1, SAT2, SAT3, and Asia1 which do not confer cross immunity. Mutation from error-prone RNA replication, recombination, and host selection generate constant new FMDV variants.

Resistance to physical and chemical action

Temperature: Preserved by refrigeration and freezing. Progressively inactivated by temperatures above 50°C. Heating animal products to a minimum core temperature of 70°C for at least 30 minutes inactivates the virus.

pH: Quickly inactivated by pH <6.0 or >9.0.

Disinfectants: Inactivated by sodium hydroxide (2%), sodium carbonate (4%), citric acid (0.2%), acetic acid (2%), sodium hypochlorite (3%), potassium peroxymonosulfate/sodium chloride (1%), and chlorine dioxide. Resistant to iodophores, quaternary ammonium compounds, and phenol, especially in the presence of organic matter.

Survival: Survives in lymph nodes and bone marrow at neutral pH, but destroyed in muscle at pH <6.0 i.e. after *rigor mortis*. Survives in frozen bone marrow or lymph nodes. Residual virus survives in milk and milk products during regular pasteurisation, but is inactivated by ultra high-temperature pasteurisation. Survives drying but may persist for days to weeks in organic matter under moist and cool temperatures. Can persist in contaminated fodder and the environment for up to 1 month, depending on the temperature and pH conditions.

EPIDEMIOLOGY

- One of the most contagious animal diseases, with important economic losses
- Low mortality rate in adult animals, but often high mortality in young due to myocarditis
- Cattle are usually the main host, although some strains appear to be specifically adapted to domestic pigs or sheep and goats
- Wildlife, other than African buffalo (*Syncerus caffer*) in Africa, has not so far been shown to maintain FMD viruses
- Evidence indicates that infection of deer in the past was derived from contact, direct or indirect, with infected domestic animals

Hosts

- All domestic cloven-hoofed animals are susceptible, including cattle, pigs, sheep, goats, and buffalo
- All wild cloven-hoofed animals are also susceptible, including deer, antelope, wild pigs, elephant, giraffe, and camelids
- Old World camels may be resistant to natural infection with some strains and South American camelids such as alpacas and llamas are mildly susceptible, but are probably of no epidemiologic significance
- African buffalo are the only wildlife species to play a significant role in the epidemiology of FMD
- Strains of FMD virus that infect cattle have been isolated from wild pigs and deer
- Capybaras and possibly hedgehogs are susceptible. Rats, mice, guinea pigs and armadillos can be infected experimentally

Transmission

- Direct contact between infected and susceptible animals
- Direct contact of susceptible animals with contaminated inanimate objects (hands, footwear, clothing, vehicles, etc.)
- Consumption (primarily by pigs) of untreated contaminated meat products (swill feeding).

- Ingestion of contaminated milk (by calves)
- Artificial insemination with contaminated semen
- Inhalation of infectious aerosols
- Airborne, especially temperate zones (up to 60 km overland and 300 km by sea)
- Humans can harbour FMDV in their respiratory tract for 24–48 hours, leading to the common practice of 3-5 days of personal quarantine for personnel exposed in research facilities
- During an active outbreak, this may be reduced to an overnight period of time after thorough shower and shampoo, change of clothing, and expectoration

Sources of virus

- Incubating and clinically affected animals
- Breath, saliva, faeces, and urine; milk and semen (up to 4 days before clinical signs)
- Meat and by-products in which pH has remained above 6.0
- Carriers: recovered or vaccinated and exposed animals in which FMDV persists in the oropharynx for more than 28 days
- The rates of carriers in cattle vary from 15–50%
- The carrier state in cattle usually does not persist for more than 6 months, although in a small proportion it may last up to 3 years
- Domestic buffalo, sheep and goats do not usually carry FMD viruses for more than a few months; African buffalo are the major maintenance host of SAT serotypes, and may harbour the virus for at least 5 years
- Circumstantial field evidence indicates that on rare occasions carriers may transmit infection to susceptible animals of close contact: the mechanism involved is unknown

Occurrence

FMD is endemic in parts of Asia, Africa, the Middle East and South America (sporadic outbreaks in free areas).

For more recent, detailed information on the occurrence of this disease worldwide, see the OIE World Animal Health Information Database (WAHID) Interface [<http://www.oie.int/wahis/public.php?page=home>] or refer to the latest issues of the World Animal Health and the OIE *Bulletin*.

DIAGNOSIS

Incubation period is 2–14 days.

Clinical diagnosis

The severity of clinical signs varies with the strain of virus, exposure dose, age and breed of animal, host species, and degree of host immunity. Signs can range from mild or inapparent to severe. Morbidity may approach 100%. Mortality in general is low in adult animals (1–5%) but higher in young calves, lambs and piglets (20% or higher). Recovery in uncomplicated cases is usually about two weeks.

Cattle

- Pyrexia, anorexia, shivering, reduction in milk production for 2–3 days, then
 - smacking of the lips, grinding of the teeth, drooling, lameness, stamping or kicking of the feet: caused by vesicles (aphthae) on buccal and nasal mucous membranes and/or between the claws and coronary band
 - after 24 hours: rupture of vesicles leaving erosions
 - vesicles can also occur on the mammary glands
- Recovery generally occurs within 8–15 days
- Complications: tongue erosions, superinfection of lesions, hoof deformation, mastitis and permanent impairment of milk production, myocarditis, abortion, permanent loss of weight, and loss of heat control ('panthers').
- Death of young animals from myocarditis

Sheep and goats

- Pyrexia. Lameness and oral lesions are often mild
- Foot lesions along the coronary band or interdigital spaces may go unrecognised, as may lesions on the dental pad
- Agalactia in milking sheep and goats is a feature. Death of young stock may occur without clinical signs

Pigs

- Pyrexia
- May develop severe foot lesions and lameness with detachment of the claw horn, particularly when housed on concrete
- Vesicles often occur at pressure points on the limbs, especially along the carpus ('knuckling')
- Vesicular lesions on the snout and dry lesions on the tongue may occur. High mortality in piglets is a frequent occurrence

Lesions

- Vesicles or blisters on the tongue, dental pad, gums, cheek, hard and soft palate, lips, nostrils, muzzle, coronary bands, teats, udder, snout of pigs, corium of dewclaws and interdigital spaces
- Erosions on rumen pillars at post mortem. Gray or yellow streaking in the heart from degeneration and necrosis of the myocardium in young animals of all species ('tiger heart')

Differential diagnosis

Clinically indistinguishable:

- Vesicular stomatitis
- Swine vesicular disease
- Vesicular exanthema of swine

Other differential diagnosis:

- Rinderpest
- Bovine viral diarrhoea and Mucosal disease
- Infectious bovine rhinotracheitis
- Bluetongue
- Epizootic haemorrhagic disease
- Bovine mammillitis
- Bovine papular stomatitis; Contagious ecthyma
- Malignant catarrhal fever

Laboratory diagnosis

Samples

- 1 g of tissue from an unruptured or recently ruptured vesicle
- Epithelial samples should be placed in a transport medium which maintains a pH of 7.2–7.6 and kept cool (see OIE *Terrestrial Manual*)
- Oesophageal-pharyngeal fluid collected by means of a probang cup. Probang samples should be frozen to below –40°C immediately after collection

NB!!	Special precautions are required when sending perishable suspect FMD material within and between countries. See OIE <i>Terrestrial Manual</i> , Chapter 1.1.1.
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Procedures

Identification of the agent:

Demonstration of FMD viral antigen or nucleic acid is sufficient for a positive diagnosis. Laboratory diagnosis and serotype identification should be done in a laboratory meeting OIE requirements for Containment Group 4 pathogens.

- Antigen ELISA – detects FMD viral antigen and identifies serotype; preferred over CF test
- Complement fixation test – less specific and sensitive than ELISA; affected by pro- and anti-complement factors
- Virus isolation:
 - Inoculation of primary bovine (calf) thyroid cells or primary pig, calf and lamb kidney cells; inoculation of BHK-21 and IB-RS-2 cell lines; inoculation of 2-7 day old unweaned mice
 - Once cytopathic effect is complete, culture fluids (or musculo-skeletal tissues from dying mice) can be used in CF, ELISA or PCR tests
- RT-PCR – recognises nucleic acids of agent; rapid and sensitive; samples: epithelium, milk, serum, OP
 - Agarose gel-based RT-PCR
 - Real-time RT-PCR
- Electron microscopic examination of lesion material

Pen-side tests: now commercially available

Serological tests

- prescribed tests in the OIE *Terrestrial Manual*
 - Virus neutralisation test
 - ELISA – Solid-phase competition ELISA or Liquid-phase blocking ELISA
- alternative test in the OIE *Terrestrial Manual*
 - Complement fixation test

For more detailed information regarding laboratory diagnostic methodologies, please refer to Chapter 2.1.5 Foot and mouth disease in the latest edition of the OIE *Manual of Diagnostic Tests and Vaccines for Terrestrial Animals* under the heading “Diagnostic Techniques”.

PREVENTION AND CONTROL

Sanitary prophylaxis

- Protection of free zones by border animal movement control and surveillance.
- Quarantine measures
- Slaughter of infected, recovered, and FMD-susceptible contact animals
- Cleaning and disinfection of premises and all infected material, such as implements, cars, and clothes (OIE *Terrestrial Code* Chapter 4.14)
- Disposal of carcasses, bedding, and contaminated animal products in the infected area (OIE *Terrestrial Code* Chapter 4.13)

Medical prophylaxis

Inactivated vaccines

These FMD vaccines contain defined amounts of one or more chemically inactivated cell-culture-derived preparations of a seed virus strain blended with a suitable adjuvant/s and excipients. Oil adjuvants are preferred in swine, but can also be used in ruminants, and may have advantages from less interference with maternal antibody and longer duration of immunity. FMD vaccines may be classified as either 'standard' or 'higher' potency vaccines.

- Standard Potency Vaccines (commercial vaccines): formulated with sufficient antigen to have a minimum potency level of 3 PD₅₀ [50% protective dose]

- Provide 6 months of immunity after two initial vaccinations given 1-month apart.
- Vaccine strains are selected based on antigenic relationship with circulating strains
- Many are multivalent to ensure broad antigenic coverage against prevailing circulating strains
- Higher Potency Vaccines (emergency vaccines): formulated with sufficient antigen to have a minimum potency level of 6 PD₅₀ [50% protective dose]
 - Higher potency vaccines are formulated with an increased amount of antigen such that the potency is in excess of the minimum requirement to provide particular features such as a more rapid onset of immunity and a wider spectrum of immunity against relevant field viruses
 - Higher potency vaccines are thus well suited for emergency use

Live attenuated vaccines

Not acceptable due to danger of reversion to virulence and prevention of DIVA technique for differentiating infected from vaccinated animals.

For more detailed information regarding vaccines, please refer to Chapter 2.1.5 Foot and mouth disease in the latest edition of the *OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals* under the heading “Requirements for Vaccines and Diagnostic Biologicals”.

For more detailed information regarding safe international trade in terrestrial animals and their products, please refer to the latest edition of the *Terrestrial Animal Health Code*.

REFERENCES AND OTHER INFORMATION

- Brown C. & Torres A., Eds. (2008). - USAHA Foreign Animal Diseases, Seventh Edition. Committee of Foreign and Emerging Diseases of the US Animal Health Association. Boca Publications Group, Inc.
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- Spickler A.R. & Roth J.A. Iowa State University, College of Veterinary Medicine - <http://www.cfsph.iastate.edu/DiseaseInfo/factsheets.htm>
- World Organisation for Animal Health (2009). - Terrestrial Animal Health Code. OIE, Paris.
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The OIE will periodically update the OIE Technical Disease Cards. Please send relevant new references and proposed modifications to the OIE Scientific and Technical Department (scientific.dept@oie.int). Last updated October 2009.