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FOOT AND MOUTH DISEASE: RISK FACTORS AND CONTROL MEASURES (REVIEW)

Toshtemirova Mokhira Makhmud kizi
Samarkand State Medical University
Assistant of the Department of Therapeutic Dentistry
Otaboyev Abrorbek O'tkirbek o'g'li
Samarkand State Medical University
Abdullayeva Maftuna Nizomiddin kizi
Samarkand State Medical University

Introduction: Foot-and-mouth disease (FMD) is classified by the World Organization for Animal Health (OIE) as a Schedule A disease. Given the potential for rapid spread of the disease, all suspected cases should be reported and investigated immediately. Understanding the mechanism of FMD spread and control measures is key to outbreak investigation and allows the source of an outbreak to be traced along with potential routes of further spread. Foot-and-mouth disease is endemic in vast areas of Africa, Asia and South America. In 2022, the following countries remain unfavorable for FMD: Kazakhstan, Mongolia, China, Israel, Indonesia, UAE, Palestine, Algeria, Botswana, Zambia, Zimbabwe, Malawi, Mozambique, Tunisia, South Africa. In Russia, in 2022, foot and mouth disease was not registered. There are seven serotypes of foot-and-mouth disease virus: O, A, C, Asia 1, SAT 1, SAT 2 and SAT 3. Cattle, buffalo, sheep, pigs, goats, African buffalo, deer, yaks and other artiodactyls are susceptible to it. The two principle ways in which an animal can become infected are by inhalation of virus particles in the air, and by ingestion of food material containing virus particles, also through abrasions, contaminated instruments or artificial insemination. Up to 50 % of ruminant animals become persistently infected after clinical recover and termed a "carrier". Key risk factors for virus introduction are the introduction of a new animal into the herd with an unknown FMD vaccination status, seasonality, lack of vaccination, herd size. The cause of infection is often the uncontrolled or illegal movement of livestock. The main risk of FMD introduction comes from livestock, vehicles, people directly working with livestock susceptible to FMD, wild animals. The key principles of biosecurity are isolation of sick animals, cleaning and disinfection of premises and equipment. Foot-and-mouth disease is a major barrier to international trade in livestock and animal products, so countries free of the disease are taking increased precautions to prevent the virus from entering.
Key words: virus, etiology, spread, prevention.

Understanding the mechanism of spread of FMD and its control measures is key to outbreak investigations and allows tracing the source of an FMD outbreak along with potential pathways for further spread. This process is critical in fighting the disease.

The purpose of the review is to summarize current scientific data on the epizootology, pathogenesis, diagnosis and prevention of foot-and-mouth disease in order to assess the risk of introduction and spread of the disease to free territories.

Material and methods. The search for sources was carried out by screening international scientific citation databases Web of Science, PubMed, Scopus, Google Scholar, Mendeley and the Russian Science Citation database. After eliminating duplicate and unverified data and selecting publications that fully correspond to

the purpose of the work, 52 sources were selected.
Main part. Etiology**.** Foot-and-mouth disease virus is a small non-enveloped RNA virus (family Picornoviridae, genus Aphtovirus). The absence of an envelope indicates that the virus is highly resistant in the environment. In addition, RNA viruses exhibit frequent spontaneous mutations, leading to the emergence of new lineages of the virus.
Based on their antigenic structure, there are seven immunologically distinct serotypes of foot-and-mouth disease virus with indistinguishable clinical signs: O, A, C, Asia 1, SAT (South African Territories) 1, SAT 2 and SAT 3. Recovery from infection or protective vaccination against one serotype will not protect from subsequent infection by others.
In addition to the wide variety of virus serotypes, within each of them several antigenic variants-strains can occur.
Spreading. Foot and mouth disease is endemic in large areas of Africa, Asia and South America.
Foot-and-mouth disease virus has demonstrated the ability to cross international borders and cause epidemics in previously free areas, as evidenced by the 2001 epidemic in the UK and continental Europe, and outbreaks in 2000 in Japan and South Korea. It was estimated that the direct cost of eradicating the epidemic in the UK in 2001 was 2.75 billion. The indirect costs of the combined loss of agricultural exports and trade are difficult to estimate accurately, but were likely to amount to an additional 5.25 billion.
In recent years, significant improvements in the epizootic situation have occurred in South America and Southeast Asia. Europe, North and Central America, the Pacific and Caribbean islands are officially recognized by the OIE as free from foot-and-mouth disease without vaccination. In Russia, since 2006, foot and mouth disease has been diagnosed annually. For the period 2018-2020. The territory of the Russian Federation remained unfavorable for this infection. In 2018, foot and mouth disease was diagnosed in the Trans-Baikal Territory, and in 2019 it was detected in three constituent entities of the Russian Federation. Since the beginning of 2021, foot-and-mouth disease has not been registered in Russia, but in November 2021, a new outbreak of foot-and-mouth disease was recorded in the Trans-Baikal Territory1, which was widespread.
This region often becomes unfavorable for foot-and-mouth disease, which, on the one hand, is due to its border position, and on the other, to the peculiarities of local cattle breeding - animals are grazed unattended, and timely prevention of the disease is not carried out in some cases.
Pathogenesis. Primary replication of the foot-and-mouth disease virus occurs in the upper respiratory tract, followed by viremia, resulting in fever and associated lethargy, anorexia, and decreased milk production. Secondary replication of the virus occurs in epithelial sites, including the hoof crown, tissue between the hooves, tongue, gums, teats, and heart tissue in young animals.
At the sites of secondary replication, vesicles (vesicles) are formed, which then rupture to form erosions. By the appearance of these lesions, one can estimate the period of infection of the animal, which is important for epizootological investigations. The foot and mouth disease virus is released when vesicles rupture, with exhaled air, and can also be found in all excreta.
Virus isolation can occur 2 days before or at the onset of clinical signs, but experimentally the virus can be detected in milk up to 4 days before the onset of clinical signs.
The most likely two main routes of infection of animals are airborne and nutritional.
For all species of susceptible animals, higher doses of the virus are required during alimentary infection than with a respiratory infection. Along with these primary routes of infection, animals can also become infected through abrasions, contaminated instruments or artificial insemination.
Clinical signs. Characteristic clinical signs of foot and mouth disease – depressed condition, anorexia, fever, lameness, animals often take a recumbent position, decreased milk production, hypersalivation (characteristic “smacking” sounds in cattle), vesicles and erosions on the nasal planum, inside the oral cavity, on the inner surface of the thigh and in the interclaw gap (Fig. 2), sudden death in newborn animals, abortion. Foot and mouth disease causes a severe and often debilitating condition in the acute phase, especially in cattle and pigs. Although most affected animals recover, complications such as chronic claw infections or mastitis can affect the health and productivity of animals long after the acute course of the disease.
Diagnostics. Laboratory diagnosis is used to confirm or exclude FMD after clinical suspicion. Laboratory

testing can also provide additional information useful for epidemiological investigations, such as the serotype and strain of virus present. This information is important for understanding the origin of the virus, as well as for choosing a vaccine. Depending on the stage of the disease, samples may be taken to detect the foot-and-mouth disease virus or to detect antibodies to it.

There are three key principles of biosecurity: isolation, cleaning, disinfection. At the entrance to the premises where there is a suspicion of foot-and-mouth disease, a biosecurity entry point with disinfection equipment must be installed. At the exit from the premises where there is a suspicion of foot-and-mouth disease, a biosecurity exit point with disinfection equipment should also be installed.

After confirming the diagnosis, it is necessary to determine the boundaries of the protection and surveillance zones. A protection zone is an area around a foot-and-mouth disease-infected farm with a radius of at least 3 km, within which measures are being implemented to identify new cases of foot-and-mouth disease and prevent the spread.

The surveillance zone is similar to the protection zone, but has a radius of at least 10 km. The precise boundaries of these zones do not need to be circular, but must take into account natural barriers, administrative boundaries and other relevant information.

Within the protection zone, the following measures are applied:

1. All livestock farms must be registered and a census (census) of all animals must be carried out.
2. All susceptible animals on these holdings must undergo periodic veterinary examination.
3. Susceptible animals must not be removed from their possessions except in cases of emergency slaughter under official supervision.
4. Animal products produced in the protection zone may not be sold or moved except in certain circumstances.

The measures applied in the protection zone must remain in effect for at least 15 days after the slaughter of infected animals, the first cleaning and disinfection of the infected holding and the completion of surveillance with negative results on all holdings within the zone.

The measures taken in the surveillance zone are essentially the same as those taken within the protection zone. The focus of investigations is on the protection zone, so less intensive measures may be taken in the surveillance zone.

The risk of endemization and measures to reduce it. To quickly eliminate the consequences of a foot-and-mouth disease outbreak in a previously free area and reduce the risk of endemization, it is necessary to use additional strategies to combat the disease. In addition to those described previously, control measures may also include a broader ban on livestock movement and the culling of contact animals.

The continued use of vaccinated animals affects the “waiting period” before a country can apply to the OIE for an official FMD exemption. A country previously unfavorable for foot-and-mouth disease can restore its status as a free country in three ways:

1. Slaughter of infected animals, lack of vaccination, serological surveillance to confirm the absence of infection (minimum 3 months of waiting).
2. Slaughter of infected animals, vaccination for removal (removal of all vaccinated animals from the population), serological surveillance to confirm the absence of infection (minimum 3 months of waiting).
3. Slaughter of infected animals, residual vaccination (vaccinated animals remain in the population), serological surveillance to confirm the absence of infection.

Conclusion. The epidemiological significance of foot and mouth disease is determined by various factors. Thus, a variety of hosts, the ability to infect with small doses, a high rate of replication and abundant excretion, as well as persistence determine the variety of sources of the virus, their high biological danger and the risk of untimely diagnosis.

Multiple routes of transmission of the virus, including airborne spread and uncontrolled interstate trade, contribute to its widespread and, most importantly, free spread of the disease. These circumstances dictate the need to apply strict control measures, including the slaughter of sick and potentially infected animals, and a ban on trade.

At the same time, vaccination is not a panacea for foot-and-mouth disease and a condition for lifting the embargo on trade in animals and livestock products from countries endemic for foot-and-mouth disease. The greatest risk is posed by transboundary introduction of foot-and-mouth disease both from countries

directly bordering the Russian Federation (Kazakhstan, China, Mongolia) and from countries importing livestock products and feed.

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