Diagnosis and Prevention of Swine Foot-and-mouth Disease

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Abstract This paper introduces the characteristics of swine foot-and-mouth disease from the aspects of pathogen, epidemiology, clinical symptoms, and anatomical symptoms, and puts forward clinical comprehensive diagnosis and laboratory diagnostic methods. The disease is distinguished with similar diseases, such as swine pox, porcine vesicular stomatitis, and swine vesicular disease. Finally, the prevention and control measures of the disease are proposed.

Keywords Swine foot-and-mouth disease; Pathogen; Epidemiology; Clinical symptom; Anatomical symptom; Diagnosis method; Prevention and control measure

Swine foot-and-mouth disease is an acute, febrile, highly contact-contagious disease caused by the foot-and-mouth disease virus infecting pigs. Sick pigs and infected pigs are the main sources of infection, and the infectivity is the highest in the early stage of the onset. The disease is mainly transmitted through the digestive tract, respiratory tract, damaged skin, mucous membranes, eye conjunctiva, *etc*., and can also be directly or indirectly transmitted through urine, milk, semen and saliva. In addition, birds, rodents, insects and other wildlife can also mechanically transmit the virus. Young piglets and unvaccinated pigs are frequently infected. The disease can occur throughout the year, especially prevalent in spring and fall when the climate is colder, and often spreads rapidly, occurring as a pandemic but generally a benign outcome.

1 Pathogen

1.1 Classification and structure The pathogen of foot-and-mouth disease is foot-and-mouth disease virus, belonging to *Apthovirus*, Picornaviridae. The virus is simple in structure, hexagonal or spherical in shape, with a particle diameter of 23–25 nm, and it is an icosahedron consisting of 60 structural units. The virus consists of a central ribonucleic acid core and a surrounding protein capsid, without capsule, and the intact virus contains single-stranded plus RNA and capsid protein, with a full genomic RNA length of 8.5 kb.

1.2 Physicochemical properties The virus is resistant to low-temperature environments and can survive for several months at 4–7 ℃. The blister skins preserved in 50% glycerol saline can survive for more than a year in 5 ℃ environment, and can be preserved for several years under −70– −50 ℃ environment. However, high temperature and ultraviolet light have an inactivation effect on the virus, and it can only survive for 48 h at 37 ℃; it can be inactivated at 60 ℃ in 15 min, by boiling for 3 min, or by directly exposing to sunlight for 1 h. The virus is very sensitive to both acids and bases and is 90% inactivated in a buffer solution of pH 6.5 at 4 ℃ for 14 h. For 1% NaOH solution, the virus will be inactivated in 1 min. However, the virus is very resistant to chemical disinfectants such as ether, and it will not be inactivated in 1∶1 000 mercuric solution and 3% Lysol after 6 h. It can survive in 1% carbolic acid for 5 months, and in 70% alcohol for 2–3 d.

1.3 Serotype The virus is the smallest known animal RNA virus, with seven serotypes identified by cross-protection and serological tests, namely O, A, C, SAT1, SAT2, SAT3 (*i.e*., South African types 1, 2, and 3), and Asia1 (Asian type I). Each type can be further demarcated into subtypes, and it is now known that the virus has more than 80 subtypes, with no cross-immunity between the subtypes. The cross-immunity between subtypes within the same type is different, which leads to the fact that the foot-and-mouth disease virus has the characteristics of polymorphism and easy variation.

2 Epidemiology

2.1 Source of infection and transmission routes Sick pigs and infected pigs

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are the most important sources of infection of the disease, and there are large amounts of viruses in the muscles, blood, body fluids, secretions, and excretions of sick animals. In addition, sick animals can still carry the virus for several weeks to months after they have recovered from the disease, and can also be a source of infection for the disease. The virus is most contagious in the early stages of the onset, and it is mainly transmitted through direct contact, but also through the digestive tract, respiratory tract, broken skin, mucous membranes, conjunctiva, semen and saliva and other ways of transmission.

2.2 Susceptible animals

Even-toed ungulates are most susceptible to the disease, such as pigs, cattle, sheep, camels, deer, *etc.* Mule-foot does not develop the disease. In pig herds, young piglets and unvaccinated pigs are more susceptible.

2.3 Epidemic characteristics The disease can occur throughout the year, and the virus spreads rapidly and often becomes a pandemic, especially in unimmunized farms. In addition, it often shows a cyclical epidemic every 2–5 years.

3 Clinical symptoms

3.1 Mental Symptoms Sick pigs are feverish, with body temperature rising to 40–41 ℃, reduced or abolished appetite, mental instability, and some sick pigs are lame or lying on the ground (Fig.1–1).

3.2 Vesicular lesion The skin on the bottom or crown of the pig's hoof is flushed and swollen. With the progress of the disease, one or more blisters of varying sizes similar to grains of rice, soybeans, or ping-pong balls successively appear in the hoof crown, hoof heel, hoof fork, lips, gums, tongue, mouth, muzzle, nose and nipples and other parts. Erosion of blisters on the udder and nipples of lactating sows causes pain, leading to decreased lactation or even refusal to nurse (Fig.1–2, Fig.1–3, Fig.1–4).

4 Anatomical Symptoms

Pharynx and trachea: circular vesicular exanthema and erosive foci of varying sizes are seen on the pharynx, trachea, and bronchi (Fig.2–1), and individual pigs have localized pyogenic infection, with pus-like exudates.

Fig. 1 Clinical symptoms of swine foot-and-mouth disease

Heart: there are diffuse and punctate hemorrhages in the pericardium; dissection of the myocardium reveals grayish-yellow, grayish-white speckled or streaked degenerative necrotic foci in the ventricular septum, atria and ventricles, with varying sizes and shapes, which resembles the stripes on the body of a tiger, and is called the "tiger-spotted heart" (Fig.2 –2); the myocardium is dilated, pale in color, soft(Fig.2–3), with reduced elasticity, and resembles boiled meat.

Stomach: some diseased pigs have catarrhal and hemorrhagic gastritis, and occasionally with gastric mucosal erosion (Fig.2–4).

Intestine: some sick pigs have catarrhal and hemorrhagic enteritis (Fig.2 –5, Fig.2–6, Fig.2–7).

Brain: the meninges are congested and edematous, and pitting hemorrhages often emanate from the gray and white matter of the brainstem and spinal cord (Fig.2–8).

5 Diagnosis Methods

The disease can occur throughout the year, with rapid propagation, and often becomes a pandemic, but is generally benign in its reversion. Blisters of varying sizes similar to grains of rice, soybeans or ping-pong balls appear on the hoof crown, hoof fork, mouth, lips, gums, tongue, nipples, muzzle and other parts of the diseased pig. When the dead pig is dissected, grayish-yellow, grayish-white speckled or striped degenerative necrotic foci can be seen in the ventricular septum, atria and ventricles, and there is a "tiger-spotted heart" lesion. Laboratory tests should be performed to confirm the disease.

Laboratory diagnosis mainly includes isolation and identification of viruses, virus neutralization test, enzyme-linked immunosorbent assay, RT-PCR assay, and gene chip detection technology. The isola-

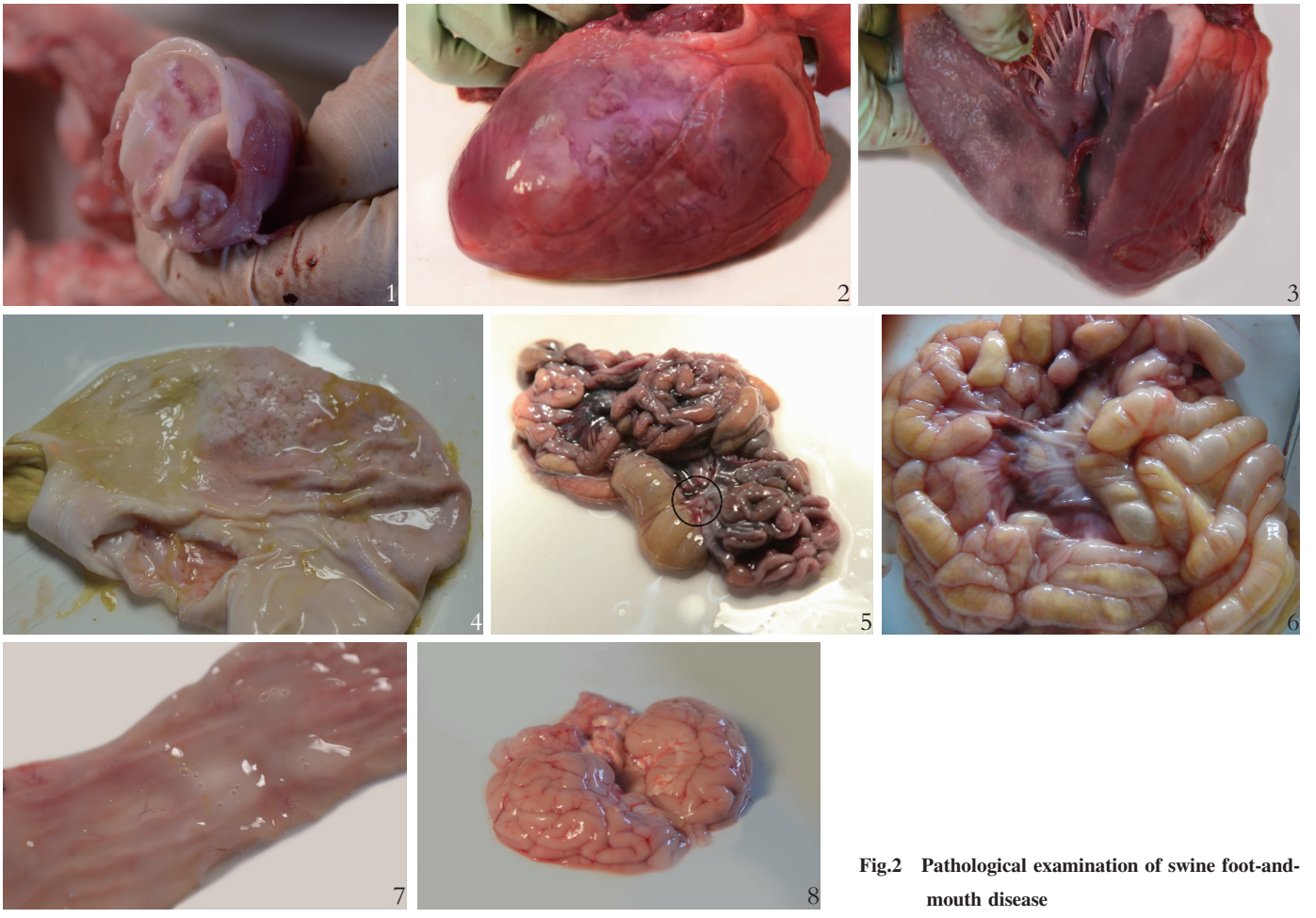

Fig.2 Pathological examination of swine foot-and-mouth disease

tion and identification of viruses is simple but time-consuming, and is mainly used for the isolation and identification of clinical materials. The virus neutralization test is time-consuming and laborious, not suitable for rapid clinical detection, and is mostly used for laboratory confirmation. The enzyme-linked immunosorbent assay (ELISA) is highly sensitive and specific, simple to perform and non-radioactive, especially the application of commercial kits and automated instruments makes it an immunolabeling technique suitable for all levels of inspection departments. The RT-PCR assay, as a method of detecting viruses, is specific, sensitive, reproducible, and simple to operate for the purpose of rapid detection. Gene chip detection technology is a high-tech technology that has been developed in recent years through the cross-fusion of molecular biology and microelectronics, and has shown important theoretical significance and wide application prospects in basic research and clinical applications such as gene expression profiling, functional genome, and genetic diagnosis of diseases. This method can be used for both the detection of antibody levels in immunized animals and the identification of immunized and naturally infected animals, but the only drawback is high requirements for instrumentation.

6 Identification of Similar Diseases

6.1 Swine pox Similarities: sick pigs all show elevated body temperature, and blisters appear on the nose and eyes, with clear exudate inside.

Differences: swine pox occurs in spring and fall when it is humid, and is mostly endemic; pigs with swine pox itch intolerably, and often grind against walls and fences; swine pox mainly occurs in the trunk, lower abdomen and lnterfemus and other hairless areas, without blisters in hooves (Fig.3–1, Fig.3–2); papules first appear and then blisters, and blisters develop into pustules, which are concave in the middle; local area is yellow due to anemia, while the surrounding tissues are swollen, and soon broken and scabbed.

6.2 Porcine vesicular stomatitis Similarities: sick pigs show elevated body temperature, reduced or absent appetite, blisters and ulcers in the nose, mouth and crown of hoof, salivation, lameness and other symptoms.

Differences: porcine vesicular stomatitis often occurs in summer and fall, and

Fig. 3 Clinical symptoms of swine pox

is mostly disseminated; there are fewer or no blisters in the hooves of sick pigs; the disease has no obvious visceral pathological changes; dairy rabbits inoculated with materials from porcine vesicular stomatitis are not infected.

6.3 Swine vesicular disease Similarities: sick pigs all show elevated body temperature, redness, swelling and pain in the skin of hoof crown, between toes and hoof heel, followed by blisters on the hoof crown and hoof heel of the main and accessory toes, which then form ulcers after rupture.

Differences: the blisters of swine vesicular disease occur firstly from the junction of hoof and skin, with rare blisters on the tongue, and sometimes blisters appear on the nipples of sows; after autopsy, there is no obvious change in internal organs, and no grayish-white or grayish-yellow stripes and spots in myocardium and skeletal muscles; inoculation of 7–9-day-old suckling rats with diseased materials of swine vesicular disease shows no obvious reaction.

7 Prevention and control measures

7.1 Prevention measures

(1) Sanitary environment. As a non-capsular virus, foot-and-mouth disease virus has strong resistance to external environmental factors and chemical disinfectants, and is sensitive to acids, aldehydes and halogen disinfectants, so disinfectants such as compound aldehydes, iodine agents, chlorine agents and peroxides can be used to disinfect the enclosure environment.

The correct disinfection procedure is as follows: the surrounding environment is first sprayed and maintained for more than 4 h, and feces, urine, garbage, mud and dirt are cleaned up thoroughly for heap fermentation or incineration; afterwards, a second spray is performed and maintained for more than 4 h, the hog house with concrete floors and transport tools are rinsed with tap water; after natural drying, a third spray is carried out, and the hog house is enabled after air dry.

(2) Vaccination. Immunization is an effective means to prevent swine foot-and-mouth disease. Routine immunization procedures are as follows: sows should be vaccinated with high efficiency vaccine at least 3 times a year, and each time should be strengthened for 3–4 months; boars should be vaccinated once every 3–4 months; reserve sows and young boars should be immunized 1–2 times before mating; piglets should be immunized for the first time 10–15 d after weaning, and then carried out booster vaccination after 4 weeks; and the whole farm should be vaccinated once every 3–4 months.

7.2 Control measures When there is a suspected case of swine foot-and-mouth disease , the epidemic should be reported to the higher authorities immediately and the diseased material should be collected and sent for examination; the site of the disease should be blocked immediately; and the hog houses, the environment and the feeding and management utensils must be strictly disinfected. Sick pigs can be slaughtered and culled centrally with the consent of the relevant departments. If no other sick pigs are found after the culling is over, the empty house must be thoroughly disinfected, and the blockade can be lifted after the house has been left empty for 15–30 d.

Emergency immunization procedures should be adopted for the same herd of pigs without onset. For the whole herd of all ages, emergency vaccination against foot-and-mouth disease with high efficiency vaccine must be carried out, and a booster vaccination must be carried out once at an interval of 15 d.

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