УДК 619:615:616.993.192.6

STREPTOCOCCUS SUIS INFECTION (DIAGNOSIS, PREVENTION AND TREATMENT)

Kasianenko Oksana
Doctor of Veterinary Sciences, Professor
Sumy National Agrarian University, Sumy, Ukraine
ORCID: 0000-0001-8453-1957
oksana_kasjanenko@ukr.net

Mingcheng Liu
Postgraduate student
Sumy National Agrarian University, Sumy, Ukraine
Henan Institute of Science and Technology, Xinxiang, China
ORCID: 0000-0002-3862-3567
liumc80@163.com

Streptococcus suis (S. suis) is an important zoonotic pathogen, which can cause serious diseases such as meningitis, pneumonia, endocarditis, polyserositis, arthritis, septicemia and abortion in pigs. In recent years, the incidence rate of streptococcal meningitis has shown a significant upward trend. For humans, the threat of S. suis is also increasing. Therefore, strengthening the prevention and control of the disease has become an urgent task.

The premise of inducing meningitis is that S. suis invades the central nervous system and breaches the blood brain barrier (BBB). Due to the presence of the blood brain barrier, even though bacteria can enter the blood through the skin mucosa and other parts, a large number of bacteria in the blood cannot enter the brain through the blood brain barrier. The body relies on this barrier to protect the brain tissue from damage and maintain the homeostasis of the central nervous system. Brain microvascular endothelial cell (BMEC) is the basic component of the blood brain barrier, and a variety of neurological diseases are related to the dysfunction of the blood brain barrier, and S. suis can interact with brain microvascular endothelial cell and then cross the the blood brain barrier to cause central nervous system infection. However, the antibiotics used to treat the infection cannot pass through the barrier to reach the therapeutic target site, which is the key to the difficulty in the control of bacterial meningitis. Therefore, elucidating the mechanism of S. suis breaking through the blood brain barrier into central nervous system is an important breakthrough in developing S. suis meningitis control strategy.

Due to long-term unjustified use of antibiotics, bacterial resistance has increased, and antibiotic treatment disrupts the normal homeostasis of the body and intestinal flora. The problems caused by long-term, large-scale use of antibiotics are becoming more and more serious. Meningitis caused by streptococcus suis can no longer be treated with conventional antibiotics. Therefore, It is necessary to have a thorough understanding of the pathogenesis of meningitis.

This article reviews the discovery the clinical signs and symptoms of the disease, pathological changes, laboratory, measures of prevention and treatment for streptococcal infection of pigs in recent years.

Key words: *streptococcus infection, suis, diagnosis, prevention, treatment*

DOI https://doi.org/10.32782/bsnau.vet.2023.3.18

Introduction. *Streptococcus suis* is a zoonotic pathogen that is the etiological factor of streptococcal infection in pigs characterized by the development of sepsis, arthritis, endocarditis and meningitis (Zhou et al., 2020; Roy et al., 2018; Zhang et al., 2018; Dai et al., 2018; Okwumabua et al., 2020). There are 35 serotypes, with serotype 2 being the most virulent. At the same time, *Streptococcus suis serotype 2 (S. suis 2)* is also dangerous for humans (Deng et al., 2018; Guo et al., 2021; Hlebowicz et al., 2019; Xia et al., 2018; Xia et al., 2019). *Streptococcus suis* can induce meningitis in humans and pigs, which not only causes significant economic losses in pig industry, but also seriously threatens public health security. Although some progress has been made in the detection of *S. suis 2*, there are still many challenges in the research of diagnosis and treatment *S. suis 2*-induced infection, especially in the aspect of prevention (LeBel et al., 2018; Liu et al., 2018; Qian et al., 2018; Vötsch et al., 2019; Wang et al., 2020).

Clinical signs and symptoms. Septicemia. Septicemic streptococcus is mainly caused by group C streptococcus, group D streptococcus, and group E streptococcus. The most acute cases often result in sudden death without any symptoms. The symptoms of the disease are more gradual and include a rise in body temperature above 41℃, muscle tremors, loss of appetite or paralysis, constipation, visual cyanosis of mucous membranes, flushing of the conjunctival membranes, and tears. The skin color in the ear root, neck, abdomen and other places is purple, and breathing difficulties appear in the later stage of the disease (Done, Williamson, & Strugnell, 2012). Death occurs within 3 days after the disease, and dark red blood flows from natural pores after death. Autopsy showed serous cavity effusion, cellulose attachment, nasal mucosa congestion and bleeding, larynx and trachea congestion, a large number of bubbles in the trachea, spleen enlargement of 1 ~ 3 times of normal, kidney swelling and bleeding, digestive tract mucosa with varying degrees of congestion and edema (G.-x. Zhang, 2012).

Meningitis. This type of suis streptococcus disease is caused by group R streptococcus and Group C streptococcus, with a small number of cases caused by L or S streptococcus infections. Diseased pigs present with

elevated body temperature, constipation, refusal to feed, and serous or mucous rhinorrhea. Soon after the disease appeared neurological symptoms, ataxia, empty chewing, spinning, hind limb paralysis, limbs were swimming. Post examination of diseased pigs showed meningeal congestion and bleeding, some of the diseased pigs had symptoms of submeningeal effusion, and white matter and gray matter were scattered in hemorrhagic spots under the section of the brain(Gottschalk & Segura, 2000).

Arthritis. This type of pig is mainly converted from the first two types of disease, the course of disease is slightly longer than the last two types, the symptoms are relatively mild, the body temperature sometimes increased and sometimes normal, mental and appetite instability, one or more joint enlargement, lameness, difficulty standing, and emaciation (Hedegaard, Zaccarin, & Lindberg, 2013). There are yellow jelly-like liquids in the joint capsule, and some are cellulose purulent substances.

Lymph node abscess. The main manifestations of infected pigs are suppurative lymphadenitis, the main lesions are mandibular lymph nodes, and sometimes the lymph nodes in the pharynx, ear and neck will also be damaged (Timoney, 2022). The lesions of lymph nodes are inflamed, swollen, palpated hard and hot pain, which will affect feeding, chewing and swallowing, and seriously affect breathing. When the purulent site ruptured, the systemic symptoms were relieved, the course of the disease was 3-5 weeks, and the mortality was low.

Pathological change. Liver. The central vein, interlobular vein and hepatic sinuses of the liver were dilated, microthrombus was formed in the cavity, fibrin was interwoven into a network, and there were a few red blood cells, neutrophils, mononuclear macrophages and lymphocytes in the network (Gelberg, 2017). Some hepatocytes showed coagulation necrosis, and some areas showed high levels of hemosiderin.

Kidney. The glomerular capillaries were dilated, there were red blood cells or cellulosic thrombosis in the lumen, the capillary endothelial cells were swollen, the glomerular volume was significantly increased, the coagulated necrosis of the renal tubular epithelium and the necrotic lesion had a large amount of neutrophils and macrophage infiltration, and the small veins around the necrotic lesion were significantly dilated and congested. There was extensive hemorrhagic necrosis in the localized renal tubules (Xu et al., 2010).

Lung. Alveolar wall thickened significantly, capillary dilatation and congestion or fibrinous thrombosis, pink serous fluid, cellulose, varying number of red blood cells and inflammatory cells can be seen in the alveolar, small vein dilatation and congestion or venous thrombosis, more Grade bronchi contained serous fluid, cellulose, red blood cells and other inflammatory products, interstitial edema widened, lymphatic vessels dilated (Lin et al., 2015).

Spleen. The volume of the white pulp was reduced, and the number of red blood cells was reduced. In the white pulp area, fragments of nuclei of necrotic cells were scattered, and white blood cells disappeared in part of the pulp area (S. Wang et al., 2022). In the red pulp area, the structure was blurred, the contour of capillaries was unclear, the number of lymphocytes was reduced, and there was a large amount of cellulose dispersed in the spleen tissue, which contained neutrophils.

Lymph node. Fibrinous exudates and more brown hemosiderin were found in the medullary area of the dilated follicular germinal center of lymphatic follicles in the cortex.

Heart. There was no obvious lesion of myocardial fibers, but the intermuscular edema widened and the intermuscular veins were dilated and congested.

Bladder. There was swelling of the epithelial cells, edema in the submembrane, loose tissue structure, and fibrinous thrombosis in the capillaries in the submembrane.

Clinical diagnosis. According to the epidemic characteristics, clinical manifestations and pathological changes of *S.suis* disease, combined with the experience of technician, preliminary diagnosis can be made intuitively. After the disease, the skin of the sick pig will show purple indigo color, which generally appears in the eartips, abdomen and buttocks in the early stage, and will gradually extend to other parts as the disease worsens (Yang et al., 2009). Flushed skin and eye conjunctiva, purplish red spots spread to the lower ear, neck and inner extremities.These symptoms of pigs can be suspected to be *S.suis* disease.

Laboratory diagnosis. Staining microscopy. Appropriate amount of diseased tissue was taken to make smear. If diseased tissue of dead pigs was collected, fresh diseased tissue had better be collected. After the smear is made, the flame is fixed for 1~2 times, and the slide is not hot when the flame is fixed. Then, the smear was dyed through four operations: primary dyeing (crystal violet staining for 1min), medium dyeing (iodine solution staining for 1min), decolorization (decolorization solution staining for 20~60s), and redyeing (casserine solution staining for 1min). Interpretation of positive results: The gram-stained pathogens were observed under a microscope, and purple round or oval pathogens were found. These pathogens were mainly arranged in pairs or short chains, and there were a few single round coccus.

Isolation culture. Disease materials were collected and inoculated into blood (including rabbit blood) AGAR medium, cultured at 37℃ for (24±2) h, and then placed on a super clean platform to observe the solid plate culture. Interpretation of positive results: Round protrusions were found on the petri dish, indicating smooth and moist grayish-white pathogenic bacteria with obvious hemolytic rings around the colony (about 1mm in diameter). The rabbit plasma coagulase test was positive.

ELISA. Based on immunoassay technology, enzyme catalyzed reaction is used to enhance the sensitivity of specific antigen and antibody reaction, which is suitable for large-scale field diagnosis of *S.suis* infection(Xia, Wang, Wei, Jiang, & Hu, 2018). A variety of new ELISA technologies have been developed, and mature commercial kits are widely used.

PCR technique. It is used for rapid and sensitive detection of *S.suis* with multiple serotypes. Multiprimer PCR is a PCR amplification technique developed on the basis of traditional PCR. Multiple pairs of specific primers are used to simultaneously amplify different DNA fragments in the PCR

system, which greatly improves the detection efficiency (Z. Liu et al., 2013). Fluorescence quantitative PCR not only has the characteristics of high amplification efficiency of traditional PCR, but also has the characteristics of high specificity, high sensitivity and high precision of spectral technology. Moreover, fluorescence quantitative PCR can distinguish between current infection and previous infection, which is an aspect that immunological analysis cannot do.

Prevention and treatment. Prevention. Pig farms should develop a reasonable immunization plan, pregnant sows are usually vaccinated with inactivated *S.suis* vaccine 4 weeks before delivery; Piglets were inoculated once at 30 days of age and 45 days of age. Gilts are inoculated again before breeding and the protection period lasts for 6 months(Cloutier et al., 2003). It is important to note that the use of antimicrobials or the addition of antimicrobials to feed should be prohibited for approximately 15 days before and after swine vaccination. In addition, the vaccine dose can be appropriately increased for pigs at full age to prevent immune failure due to insufficient dose.

In the process of breeding pig farms adopt the way of self-breeding, combined with the model of all in and all out can reduce the incidence of pig herds (Dekker et al., 2013) . If it is necessary to introduce species from off-site, it is necessary to investigate the introduced place first to ensure that the introduced place is not an epidemic area, and then strictly quarantine the introduced pigs to ensure that there is no pathogen before introduction. In the process of introduction, transportation time and distance should be reduced to avoid contact with diseased animals on the road. After the introduction to the breeding farm, quarantine observation should be carried out. After the quarantine observation, no sick pigs were found, and the introduced pigs could be mixed for breeding.

The pig house needs to maintain good temperature and humidity, especially in different seasons to ensure that the temperature and humidity in the pig house change little, to avoid the temperature mutation caused by the pig house temperature rise and fall, resulting in the pig population is not adapted to. Especially in the hot summer and cold winter weather to pay attention to the pig house to maintain a relatively constant internal environment. The pig house should do a good job of ventilation, so that the harmful gases can be discharged in time. But in winter, to grasp the coordination of ventilation and insulation, to avoid excessive ventilation caused by too low temperature.

In the process of breeding, attention should be paid to the cleaning work of the internal and external environment of the pig house, and the feces and other excrement in the house should be cleaned in time. This can reduce the breeding of pathogens. In the process of breeding to develop a regular disinfection program and procedures, regular disinfection. Disinfection should be comprehensive and thorough to avoid the breeding and long-term existence of pathogens caused by lax disinfection. The disinfectant should be replaced regularly, and the same kind of disinfectant should not be used for a long time, so as to prevent pathogens from developing resistance to the disinfectant, resulting in poor disinfection effect.

Treatment. Isolation. Pig farms should formulate reasonable disease prevention and control system according to farm conditions and breeding scale (Andres & Davies, 2015). When pigs are infected with *S.suis* only, they should be isolated first, and their contaminated enclosures and feeds should be disinfected. 5% caustic soda can be selected as the disinfectant, and the pathogens should be completely and thoroughly sprayed to kill them. Contaminated areas should be disinfected continuously for more than 7 days, and pig farms should be empty for 30 days before use. The isolation house shall be disinfected twice a day. The sick pigs shall be disinfected with 0.1% negeramine, and the ground shall be washed and disinfected with 10% bleach powder to keep the ground dry to prevent the breeding of pathogens.

Local treatment. In pigs with lymph node abscess, tissue wounds will have ulceration and discharge of pus. These secretions also contain virulent *S.suis* (Hlebowicz, Jakubowski, & Smiatacz, 2019). Generally, after the abscess is mature, a sterile blade is used to cut open a wound, squeeze out pus, and then rinse with 3% hydrogen peroxide, and then rinse with 0.1% potassium permanganate water solution, and then smear 5% iodine tincture on the wound. If the abscess festers on its own, after rinsing can apply appropriate antibiotic ointment to inhibit bacterial infection. Clean the wound once a day until the lesion recovers.

Antibiotic therapy. Pig farm in the confirmed infection of *S.suis* disease, through the drug sensitivity test to determine the choice of antibiotics for treatment. According to the results of drug sensitivity, highly sensitive antibiotic drugs can be preferred (Seitz, Valentin-Weigand, & Willenborg, 2016). If weaned piglets are infected, chloramphenicol (25mg/kg body weight) can be injected intravenously, and 5% glucose and sodium chloride injection (200~300ml) can be injected intravenously twice /day for 3 to 5 days. If the sick pigs show neurological symptoms, they can be intramuscularly injected with chlorpromazine injection of 2mg/kg once per day-1 for 2~3 days; at the same time, they can be orally injected with vitamin C solution and intravenously injected with sulfadiazine for 50~100mg/kg once or twice per day for 2~3 days.

If there is no condition for drug sensitivity test, you can choose penicillin or streptomycin for treatment, in the treatment, but also for symptomatic treatment of symptoms. Anemone can be injected into the sick pig with fever, and for the sick pig with arthritis, turpentine can be applied to the affected area, which can play the effect of pain relief and swelling. Pigs with meningitis also need to be injected with VB1.

Conclusion. Streptococcus is one of the main zoonotic diseases of pigs, which is dangerous for humans. The most etiological factor of streptococcal infection in pigs is *S. suis 2*, which is usually isolated from clinically sick piglets and is considered the most virulent subtype of the pathogen. The main ways of transmission of infection are alimentary and respiratory infections. Infected animals often develop such symptoms assepticemia, meningitis, pneumonia, wet dermatitis, peritonitis, osteomyelitis, arthritis, pharyngitis, purulent pneumonia. For a long time, specialists managed

to control this infection quite successfully, but in the last few years, due to the problem of antibiotic resistance of bacteria to medical drugs, this infection is becoming more and more widespread.

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Касяненко О. І., *доктор ветеринарних наук, професор, Сумський національний аграрний університет, м. Суми, Україна*

Мінченг Люй*, апірант, Сумський національний аграрний університет, м. Суми, Україна, Хенанський інститут науки і технологій, м. Хенань, Китай*

Стрептококова інфекція свиней (діагностика, профілактика, лікування)

Streptococcus suis (S. suis) є важливим зоонозним патогеном, який може спричинити серйозні захворювання, такі як менінгіт, пневмонія, ендокардит, полісерозит, артрит, септицемія та аборт у свиней. В останні роки рівень захворюваності на стрептококовий менінгіт демонструє значну тенденцію до зростання. Для людини S. suis також є небезпечним патогеном. Тому посилення профілактики та боротьби із захворюванням є актуальним завданням.

Передумовою індукції менінгіту є те, що S. suis проникає в центральну нервову систему та порушує гематоенцефалічний бар'єр (ГЕБ). Через наявність гематоенцефалічного бар'єру, більшість бактерій з крові не може потрапити в мозок. Організм покладається на цей бар'єр, щоб захистити тканину мозку від пошкоджень і підтримувати гомеостаз центральної нервової системи. Мікросудинні ендотеліальні клітини мозку (BMEC) є основним компонентом гематоенцефалічного бар'єру, і різноманітні неврологічні захворювання пов'язані з дисфункцією гематоенцефалічного бар'єру, і S. suis може взаємодіяти з мікросудинними ендотеліальними клітинами головного мозку, а потім проникати через гематоенцефалічний бар'єр, щоб викликати інфекцію центральної нервової системи. Однак антибіотики, які використовуються для лікування інфекції, не можуть пройти через бар'єр, щоб досягти терапевтичної цільової ділянки, що є ключем до труднощів у контролі бактеріального менінгіту. Таким чином, з'ясування механізму проникнення S. suis через гематоенцефалічний бар'єр у центральну нервову систему є важливим проривом у розробці стратегії контролю менінгіту S. suis.

Внаслідок тривалого невиправданого застосування антибіотиків підвищується резистентність бактерій, лікування антибіотиками порушує нормальний гомеостаз організму та кишкову флору. Проблеми, спричинені тривалим, широкомасштабним використанням антибіотиків, стають дедалі серйознішими. Менінгіт, викликаний streptococcus suis, більше не можна лікувати звичайними антибіотиками. Тому необхідно мати глибоке розуміння патогенезу менінгіту. У цій статті розглядається дані щодо клінічних ознак і симптомів хвороби, патологічних змін, лабораторної діагностики, заходів профілактики та лікування стрептококової інфекції свиней за останні роки.

Ключові слова: *стрептококова інфекція, свині, діагностика, профілактика, лікування.*