SWINEPOX VIRUS

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SUMMARY

Etiology

- Swinepox virus (SwPV) is an enveloped DNA virus in the family *Poxviridae*; it is the only member of the genus *Suipoxviru*s and there is little genetic variability among strains.

Cleaning and Disinfection

- SwPV can persist in the environment, even in dry conditions.
- SwPV is susceptible to most common forms of disinfectants including acid treatment, alcohols, aldehydes, alkalis, biguanides, halogens, oxidizing agents, phenolic compounds, and quaternary ammonium compounds.

Epidemiology

- Swine are the only natural hosts for SwPV. Humans are not affected; however, SwPV in pigs cannot be easily distinguished from vaccinia virus (VV), which is zoonotic.
- SwPV is found worldwide.
- Morbidity can be very high in pigs up to four months of age. Mortality is generally low (<5%), although congenital infections are frequently fatal.

Transmission

- SwPV is mechanically transmitted by the hog louse, *Hematopinus suis*, and possibly by biting flies (*Stomoxys calcitrans*) and black flies (*Simuliidae*). Pig-to-pig transmission can also occur.

Infection in Swine/Pathogenesis

- Classic pox disease is characterized by formation of macules, followed by progression to papules, vesicles, pustules, and crusts. Secondary bacterial infections can also occur.
- Disease primarily occurs in pigs up to four months of age, while infection in adults is typically self-limiting.

Diagnosis

- SwPV may be cultivated in a range of host cells *in vitro.* Immunofluorescence and immunohistochemistry are used to detect SwPV antigens in infected epithelium.
- A polymerase chain reaction (PCR) assay has been developed for rapid detection and differentiation from the clinically similar and zoonotic vaccinia virus (VV).

- Tests to detect antibody include agar gel diffusion precipitation tests, immune-electroosmophoresis, and serum neutralization.

Immunity

- Recovered animals are immune to reinfection.
- There are currently no available vaccines against SwPV.

Prevention and Control

- SwPV is associated with poor sanitation, making cleaning and disinfection an important preventive measure.
- Swine can be treated with anti-parasitic drugs or insecticides to reduce lice infestation.

Gaps in Preparedness

- To reduce congenital infections, which are often fatal, further research is required to better understand SwPV pathogenesis and viremia in sows.

OVERVIEW

Swinepox virus (SwPV), a member of the family *Poxviridae,* is the cause of a highly contagious, self-limiting, cutaneous disease characterized by generalized pustular lesions in swine. SwPV is not a zoonotic virus and does not pose a threat to human populations.

SwPV infection occurs worldwide. SwPV is associated with poor sanitation, and its primary means of transmission is the hog louse, *Hematopinus suis*, which serves as a mechanical vector. SwPV can also be detected in nasal and oral secretions and transmission thorough direct contact has been documented. Very high morbidity can occur, especially in piglets 3–4 months of age. Congenital infections are severe and frequently result in death. SwPV-induced disease in adults is minimally pathogenic, self-limiting, and of minimal economic impact.

Despite its host restriction, SwPV may be cultivated in a range of host cells *in vitro.* SwPV can be detected in infected epithelium, dried scabs, and nasal and oral secretions. A polymerase chain reaction (PCR) assay has been developed for rapid detection and differentiation from the clinically similar and zoonotic vaccinia virus (VV). Differentiation between SwPV and VV is critical, as VV can be transmissible to other livestock and humans. Immunofluorescence and immunohistochemistry are also used to detect SwPV antigens in infected epithelium.

Due to the sporadic occurrence and minimal pathology associated with SwPV, vaccines have not been developed against the disease. However, SwPV is commonly used as a live-vector to express immunogenic proteins of a wide variety of bacteria and viruses to immunize an array of animals.

While SwPV does not largely impact swine production worldwide, further research on the prevention of congenital infections could curb mortality in infected neonates.

LITERATURE REVIEW

1. Etiology

1.1 Key Characteristics

SwPV is a double stranded, cross-linked, enveloped DNA virus in the family *Poxviridae*.[2] SwPV is the sole member of the genus *Suipoxvirus*, one of eight genera of the subfamily *Chordopoxvirinae*.[3] SwPV virions visualized by electron microscopy have a complex morphology in a characteristic poxvirus form, with a surface of 200–250 nm.[4] SwPV contains a conserved central core of 106 genes similar to other members of the *Chordopoxvirinae*.[3]

1.2 Strain Variability

As the only member of the genus *Suipoxvirus*, there is little genetic variability among strains. The genome of a prototypic strain, SwPV-Nebraska (SwPV-N), has been mapped and analyzed.[3] Other strains analyzed from various geographic locations have shown 100% nucleotide identity with SwPV-N.[1,7]

2. Cleaning and Disinfection

2.1 Survival

SwPV is very resistant to changes in environmental conditions and may persist for up to a year in desiccated conditions.[10]

2.2 Disinfection

As an enveloped virus, SwPV is easily inactivated by ether.[11] SwPV is also susceptible to most common forms of disinfectants including acid treatment, alcohols, aldehydes, alkalis, biguanides, halogens, oxidizing agents, phenolic compounds, and quaternary ammonium compounds.[12]

3. Epidemiology

3.1 Species Affected

SwPV is host-specific and generally only causes disease in swine.[13] Rabbits can be experimentally infected by intradermal inoculation but a nonproductive infection results.[14]

3.2 Zoonotic Potential

SwPV is not a zoonotic virus. SwPV-induced disease can be difficult to distinguish from clinical disease caused by VV, which can be zoonotic.[1]

3.3 Geographic Distribution

SwPV has a worldwide distribution and is endemic in many swine populations in both developed and underdeveloped countries.[2] SwPV has been reported in North America[15], Brazil[1], Europe[7], and Oceania.[1]

3.4 Morbidity and Mortality

SwPV has extremely high morbidity in pigs up to 4 months old, ranging from 80–100%.[1,3] An evaluation of seroprevalence in swine in the Netherlands detected anti-SwPV antibodies in 7.8% of pigs tested.[14] A surveillance study of swine in the United Kingdom found 19.3% of sows were seropositive for anti-SwPV antibodies.[6] Of the 69 herds tested, 20 were positive for anti-SwPV antibodies.[6] Mortality from SwPV is generally less than 5%, though congenital SwPV is frequently fatal.[1]

4. Transmission

SwPV is mechanically transmitted by the hog louse, *Hematopinus suis*.[8] Hog lice have a predilection for the ears, neck, skin folds, and the medial aspect of thighs.[9] The life cycle of *H. suis* is temperature dependent, and cool weather can delay egg hatching by up to 20 days.[9] *H. suis* prevalence in pig populations is variable and geographically dependent, ranging from 96.1–100% of pigs in Kenya to 2.5% in Germany.[9,17,18] Poor body condition and outdoor housing increases susceptibility to lice infestation.[18] Biting flies (*Stomoxys calcitrans*) and black flies (*Simuliidae*) have been implicated as mechanical vectors for SwPV and usually produce lesions in non-characteristic locations, including the dorsum, sides, and snout.[5,8] Pig-to-pig transmission can also occur.

5. Infection in Swine / Pathogenesis

SwPV causes generalized cutaneous disease typical of classic pox diseases; it is characterized by formation of a macule, followed by progression to papule, vesicle, pustule, and crust.[5] SwPV enters a break in skin through an insect bite or abrasion. The virus replicates in the cytoplasm of cells of the stratum spinosum causing hydropic degeneration.[5] Lymphadenitis of regional lymph nodes may occur, but SwPV cannot be isolated from the lymph nodes.[5] Resulting secondary lesions result from spread of the SwPV from existing lesions and not from viremia.[5] However, congenital infections are most likely the result of low-level viremia in the sow.

The incubation period under field conditions is usually fourteen days, but can be as short as five days.[5] SwPV encodes genes involved in immune modulation and evasion within the host.[3] SwPV replication peaks at 24 hours post-infection *in vitro* and continues to accumulate after 48 hours.[16] Viral proteins become evident 24-48 hours post-infection.[16] SwPV induces cytopathic effect (CPE) four days post-infection and remains localized to self-contained foci with little immediate effect on the surrounding monolayer of cells *in vitro.*[16]

5.1 Clinical Signs

SwPV causes a cutaneous disease characterized by generalized pustular lesions primarily in piglets up to four months of age.[1] SwPV infection in adult pigs is frequently self-limiting with limited pathogenic potential, and is of little economic importance. Healing time may be extended by the incidence of secondary bacterial dermatitis.[10] Secondary dermatitis may obscure the primary condition unless affected individuals are examined early in the course of the disease.[8] Slight febrile reactions and lymphadenitis of regional lymph nodes draining affected skin are the only systemic manifestations.[11]

Congenital infections have been reported and are the most severe clinical manifestations of SwPV.[7] It is thought that congenital infections result from low-level viremia in infected sows.[7,13] Lesions in infected neonates are diffusely distributed, including lesions on the distal extremities and perioral epithelium, restricting movement with decreased nursing capability. Congenital infection frequently results in death.[5,10]

In one study, one-week-old gnotobiotic piglets inoculated with purified virus by skin scarification produced vesicles at six days-post-infection, which progressed to pustules and scabs and resolved by day 14 in the absence of fever.[6] A study in the Netherlands reported a total of four congenital infections from separate litters. Each litter had a single infected piglet out of 8–11 piglets per litter.[7] Two piglets died three days after birth, one piglet was stillborn, and one was humanely euthanized 28 hours after birth due to its condition.[7]There is also a report of a congenitally infected piglet with one centimeter erosions and diffusely distributed vesicles filled with purulent material.[4] Compartmentalization of porcine fetal membranes and low-level viremia in sows may explain the low rate of infection in an individual litter.[7] Pustular and ulcerative lesions on the tongue and hard palate have also been reported in piglets.[10]

5.2 Postmortem Lesions

Ballooning degeneration and numerous eosinophilic, intracytoplasmic inclusion bodies within keratinocytes are classic histologic findings in poxvirus infection.[6] Intracytoplasmic inclusion bodies with central nuclear clearing within infected epithelial cells is pathognomonic for SwPV infection.[5] SwPV infection produces intercellular edema progressing to necrosis, cleavage, and vesicle formation, which then convert to pustules due to inflammatory cell migration.[4] Necrosis is evident in the center and superficial aspect of lesions.[7] The development of pustules indicates a highly developed chemotactic response in late term pig fetuses.[4] Viral inclusion bodies have been detected in oral mucosal epithelium in piglets with congenital infection.[10] The number of lymphocytes and neutrophilic and eosinophilic granulocytes varies among lesions.[7]

6. Diagnosis

6.1 Clinical History

SwPV should be among differential diagnoses in any case of pustular disease of high morbidity, particularly in pigs three to four months of age, louse-infested pigs, or piglets with lesions present at birth. SwPV can be differentiated from other potentially clinically similar congenital diseases (such as VV, parvovirus, ringworm, insect bites, allergic skin reactions, streptococcal/staphylococcal epidermitis) by the presence of intranuclear inclusion bodies.[5]

6.2 Tests to Detect Nucleic Acids, Virus, or Antigens

A one step duplex PCR assay for detection of SwPV DNA has been developed. Primers target internal regions of the SwPV-149 gene, which encodes a tumor necrosis factor (TNF) binding protein that is unique from other poxviruses.[19] This PCR assay amplified a 273-bp fragment of the SwPV-149 gene only when samples infected with SwPV were used, and was negative for all other genera of *Poxviridae*.[19] It is also able to rapidly differentiate between SwPV and VV.

Electron microscopy can be used to diagnose SwPV. SwPV is cultivatable in porcine kidney cells. Although SwPV is host-restricted *in vivo,* it is capable of growing in a broad range of host cells *in vitro.* Significant levels of viral replication can be achieved and virus can be serially passaged in some non-swine cell lines including African green monkey kidney cells (CVI-1), human cervix cells (HeLa), Syrian hamster kidney cells (BHK-1), and rabbit corneal cells (SIRC).[20] Immunofluorescence and immunohistochemistry has been used to detect SwPV antigens.[11]

6.3 Tests to Detect Antibody

Agar gel diffusion precipitation tests and immune-electroosmophoresis have been used to detect anti-SwPV antibodies by immunoprecipitation.[14] Serum neutralization tests have been used to determine seropositivity.[14]

6.4 Samples

6.4.1 Preferred Samples

SwPV antigen has been detected in active lesions, scabs, and nasal or oral secretions of SwPV-infected pigs.[5]

6.4.2 Oral Fluids

SwPV has been detected in nasal and oral secretions of infected animals, serving as a reservoir for horizontal transmission to other pigs.[5]

7. Immunity

7.1 Post-exposure

Precipitating antibody was first detected 20 days post-infection in Dutch swine and persisted for at least 80 days.[14] It is unknown whether the lasting antibody response is protective. Recovered animals are immune to reinfection even in the absence of demonstrated neutralizing antibody, indicating the importance of cell-mediated immunity against SwPV.[5] The conversion of vesicles to pustules via the migration of inflammatory cells demonstrates a strong chemotactic response.[4]

7.2 Vaccines

Vaccines have not been developed due to the limited pathogenicity, low mortality, and negligible economic impact of SwPV infection. Due to its host-restriction, SwPV has been utilized as an effective live-vector for expression of immunogenic proteins from a wide range of other viruses and bacteria in a variety of animals.[13]

7.3 Cross-reactivity

SwPV is immunologically and antigenically distinct from other members of the *Poxviridae.* It was classified into its own genus within the family based upon the lack of cross-reactive neutralizing antibodies.[16] No serologic relationship exists between VV and SwPV as observed in cross neutralization and cross immunity experiments.[4] Very few, if any, shared epitopes exist between SwPV and VV.[16]

8. Prevention and Control

Mechanical cleaning and maintenance of facilities serve as the best measures to prevent SwPV outbreaks. Routine treatment of pigs with anti-parasitic drugs or insecticides can reduce lice infestation and decrease SwPV vectors. Adequate sanitation and quarantine of sick animals are necessary measures to prevent illness and outbreaks.

9. World Organization for Animal Health (OIE) Terrestrial Animal Health Code

SwPV is not covered in the 2015 OIE Terrestrial Animal Health Code and there are no recommendations on importation of swine or pork.

10. Gaps in Preparedness

SwPV is the cause of a mild, highly contagious, cutaneous disease that is self-limiting. Due to the virus' environmental resistance and its mode(s) of transmission, cleaning and disinfection of swine facilities is of the utmost importance to prevent and control disease. Further research is required to better understand SwPV pathogenesis and viremia and the role it plays in congenital infections.

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