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EQUINE ARTERITIS VIRUS: A REVIEW OF CLINICAL FEATURES AND MANAGEMENT ASPECTS

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SUMMARY

Sero-epidemiological surveys have revealed that equine arteritis virus (EAV) is prevalent in most European countries. The virus causes sporadic cases of respiratory disease and abortion in horses, the incidence of which has increased in recent years. Mares and geldings eliminate virus after acute infection, but 30% to 60% of stallions become persistently infected. In these animals, EAV is maintained within the reproductive tract and is shed continuously in the semen. Persistent infection with EAV in stallions has no negative consequences for fertility but mares inseminated with virus-contaminated semen can have an acute infection. These mares shed large amounts of virus in respiratory secretions and urine, leading to lateral spread of the virus to other susceptible horses. Acute infection at later stages of gestation can lead to abortion. Effective control of the spread of EAV infection depends on the identification of virus-shedding stallions. Persistently infected stallions should not be used for breeding or should be bred only to seropositive mares. Mares bred to shedding stallions should be isolated from other animals for a period of 3 weeks following insemination to prevent the lateral spread of EAV.

INTRODUCTION

Equine arteritis virus (EAV) is a member of a group of viruses which has recently been designated as a new family, the Arteriviridae. Additional members of this group include lactate dehydrogenase-elevating virus (LDV) of mice, porcine respiratory and reproductive syndrome virus (PRRSV; also called Lelystad virus), and simian haemorrhagic fever virus (SHFV). Virions are composed of a single-stranded RNA genome of positive polarity within an isometric nucleocapsid and an envelope containing at least three structural proteins (12, 13, 24, 25).

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The virus was initially isolated from fetal lung after an outbreak of a respiratory illness that was accompanied by abortion (14, 16). Reports of an illness which resembled equine viral arteritis (EVA) and which could be transmitted venereally to mares have been published as early as 1888 (2, 38), suggesting that EAV has been present as an infectious agent within the equine population for a long time. The outbreak of equine viral arteritis which occurred in thoroughbreds in the USA in 1984 (42) led to enhanced interest in EAV in both the veterinary and international regulatory communities. The increased awareness of the presence of EAV and of its epidemiology has resulted in legislation within the EU which prohibits the presence of persistently infected stallions on a breeding facility which is engaged in the international trade of semen (38A). The purpose of this review is to summarize the current state of knowledge concerning clinical aspects of EAV infection and to provide recommendations for rational management decisions.

PREVALENCE AND GEOGRAPHIC DISTRIBUTION

EAV has a worldwide distribution and can infect both horses and donkeys (37, 44). On the European continent, horses with virus-neutralizing antibody titres have been identified in virtually every country. The percentage of seropositive horses varied in different surveys from around 6% to over 90% (4, 19, 27, 28, 35, 49). The higher rates of seropositivity have been reported in specific groups of horses, with Austrian state-owned stallions of Haflinger, Noriker, Warmblood, and Lipizzan breeds as well as American Standardbreds showing seropositivity rates of between 50 and 94% (4, 31). A serological survey done in the Netherlands with blood samples collected between 1963 and 1975 indicated that 14% of the horses tested had neutralizing antibodies to EAV (11). The incidence of seropositivity and virus-neutralizing antibody titres generally increase with age, sugges-ting that the virus circulates within the equine population (4). Recent studies have shown that the number of EAV-seropositive horses has increased dramatically within the last years, indicating that exposure to this agent is increasing (17). The recently described outbreaks in Germany,

Great Britain, the Netherlands, and Spain may be a reflection of the increased exposure of the equine population to this agent (17, 21, 34, 48, 50, 51).

CLINICAL CHARACTERISTICS OF EAV INFECTION

ACUTE INFECTION

Most infections with EAV result in subclinical or barely detectible illness. The appearance and/or severity of clinical signs is associated with the age and health status of the infected animal, the virus isolate, and the route of infection. Mares infected venereally will often have subclinical infections (43), while very young and older horses, as well as stressed animals, tend to develop clinically apparent infections. Clinical signs are characterized by fever up to 41°C, depression, anorexia, limb and ventral oedema, periorbital oedema, conjunctivitis, lacrimation, nasal discharge, and urticaria (44). A leucopenia involving both neutrophils and lymphocytes is evident at the onset of pyrexia or shortly thereafter (3). Severe clinical signs include respiratory distress, colic, and diarrhoea and are more often seen in neonates and foals (5, 20, 47). Clinical symptoms typically begin 3 to 14 days following exposure to virus and persist for 5 to 9 days. Infection can be fatal in the case of young animals, otherwise mortality is rare. Mares and geldings make an uncomplicated recovery and clear virus from their system within a month after infection (44). In stallions, the virus can establish a persistent infection (see below).

ABORTION

A common sequel to EAV infection in pregnant mares is abortion. Abortion can occur whether or not the mare has clinical signs of EVA. The fetus is usually expelled partly autolysed, but can be expelled fresh, and gross lesions are not common (9, 26, 44). When lesions are present, they can include small petechial haemorrhages on pleural and peritoneal surfaces, oedema of mediastinal and mesenteric tissues, congestion and oedema of mediastinal and mesenteric lymph nodes, epicardial and endocardial haemorrhages, and accumulation of small amounts of clear fluid within the pleural cavity (14). Virus can be readily isolated from most tissues and fluids of the aborted fetus and as a result, the fetus serves as a source of virus which can infect other susceptible animals.

Abortions can occur at the end of the acute phase or during the convalescent phase of infection (14, 26). Abortions have been observed from 3 to over 10 months of gestation. The incidence of abortion may vary widely in natural outbreaks and has ranged from less than 10% to slightly more than 60% (44). Mares infected late in gestation may deliver a premature, weak foal that dies shortly after birth (26) or a normal appearing foal that subsequently develops clinical signs of disease (47). Mares previously exposed to EAV by vaccination with a modified-live vaccine appear to be protected from abortion on re-infection with the virus (15, 30).

PERSISTENT INFECTION IN STALLIONS

After acute infection, approximately 30% to 60% of stallions will become persistently infected with EAV (45, 46). Virus persistence is maintained in the male reproductive tract within the accessory sex glands and is testosterone-dependent (29, 36). Persistently infected stallions that were castrated but were administered testosterone continued to shed virus, while those that were not given testosterone after castration stopped shedding virus after 26 days, with the exception of one animal which continued to shed small amounts of virus until day 34, after which the study ended (29). The cell type in which the virus persists has not been identified, but its presence is likely to also be testosterone-dependent.

The mechanism by which persistent infection is established is not known, but sexual maturity may be a contributing factor. The reproductive tracts of two colts not yet in puberty were shown to harbour EAV for up to 6 months after infection, but virus was not detected in five other colts at later times (22). One out of a group of nine peripuberal colts became persistently infected and virus could be detected in the semen of this colt 15 months after infection (22). Out of 22 peri- and prepuberal colts examined at times equal to or greater than 120 days post infection, only 3, or 13.6%, had detectible virus within the accessory glands of the reproductive tract. This contrasts with the findings for mature stallions infected with the same virus isolate, of which 62% became persistently infected (36).

Persistently infected stallions shed virus continuously in the sperm-rich fraction of the ejaculate. Intermittent virus shedding has never been demonstrated. Virus in semen survives chilling and freezing (44) and venereal infection is an efficient means of transmitting the virus, with 85 to 100% of seronegative mares converting after being bred to stallions shedding virus (44).

The duration of the carrier state can vary. Both a short-term carrier state, lasting several weeks and a long-term carrier state, lasting years, have been described (45, 46). More recent evidence indicates that an intermediate carrier state, lasting several months, can also occur. In exceptional cases, permanent clearance of virus has been observed after periods of persistent infection ranging from 1.5 to 10 years (44).

Persistent infection with EAV appears to have no effect on sperm quality or the health of the stallion (4, 46). Its sole negative consequence is the transmission of the virus to sus-ceptible mares during breeding. Subclinical infection of mares infected venereally is common and there are no reported effects on conception rate as a result of infection (4, 46).

TRANSMISSION

There are two ways in which EAV has been demonstrated to be transmitted between horses. The first is the venereal route described above. Shedding stallions can only infect other animals by direct contact with contaminated ejaculates. A virus reservoir is maintained in the persistently infected stallion and there is evidence to suggest that these horses have been responsible for the introduction of EAV into susceptible populations through natural or artificial insemination of mares with contaminated semen (44).

The second is through contact with an acutely infected animal. Acutely infected horses shed large amounts of virus in respiratory secretions and urine (32A). The virus spreads readily through a group of susceptible animals through aerosol transmission and direct contact with contaminated objects (8, 32). Close contact between animals is generally required for efficient virus spread.

A schematic representation of the two ways in which EAV can be transmitted is presented in figure 1. The aerosol transmission of EAV more often results in clinical symptoms and can result in abortion. It also is the means by which most susceptible stallions become exposed to, and persistently infected with, the virus.

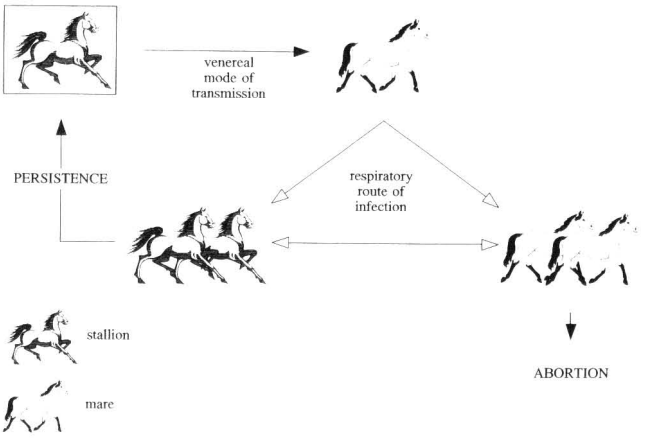

Figure 1. Schematic representation of ways in which EAV infection can be acquired. The persistently infected stallion infects a mare through virus in semen. This mare serves as a source of virus for other horses by shedding virus in respiratory and/or urinary secretions.

DIAGNOSIS

Acute infections can be diagnosed by virus isolation or by evidence of seroconversion in serum samples taken during the acute phase and 21 to 28 days later. Appropriate samples from which virus can be isolated during acute infection are citrated, EDTA or heparinized blood and nasal swabs or washings. Swabs should be placed in a suitable transport medium and shipped chilled or frozen at below -20°C to a diagnostic laboratory. Blood should be shipped chilled. In the case of abortion, fetal tissues such as lung and lymphoid tissue and placenta should be sterilely obtained, chilled, and submitted for virus isolation. Test results generally take 2 to 4 weeks to obtain.

There are two tests available to detect EAV-specific antibody. The first is the virus neutralization test which measures neutralizing antibody titres against a reference strain of the virus, currently the Bucyrus isolate (40). As yet this is the only test accepted for export/import authorization. It is relatively expensive, laborious, and takes about 4 days to complete. Tests are considered positive if neutralization is detected at a serum dilution of 1:4 or above.

A commercial ELISA for the detection of antibodies is also available. The antigen used is inactivated whole virus derived from cell culture. This test produces a relatively high number of positive results which cannot be confirmed by virus neutralization (10) and is not recommended for definitive determination of serological status. It may be useful for initial screening when a large number of horses have to be tested. Positive test results can then be confirmed with the neutralization test.

Persistent infection in stallions can be detected by initial screening to determine serological status. If seropositive in a neutralization test at a titre of 1:4 or above, the semen should be tested for the presence of virus. This can be done by test breeding to two seronegative mares and monitoring them for seroconversion. This test is required by the importation regulations of Australia. Virus can also be detected by direct virus isolation from the semen. The sperm-rich fraction should be collected and shipped immediately, chilled, to an appropriate laboratory. If the sample cannot be delivered to the diagnostic facility within 24 hours, it should be frozen at below -20°C and shipped under these conditions. Submission of processed semen samples may result in an inaccurate test result (false negative).

Additional tests are currently being developed to allow the rapid and sensitive detection of both virus and antibody. Direct detection of virion RNA in semen and tissues by reverse transcriptase/polymerase chain reaction amplification (RT/PCR) offers a promising future alternative to virus isolation (1, 6, 39, 41). Detection of viral RNA in semen samples by RT/PCR is routinely being used in Germany and Sweden, but the test is not yet commercially available elsewhere in Europe. As more information about sequence variability among EAV isolates becomes known, this may become the test of choice for the detection of virus.

Alternative ELISA tests for the detection of antibody are also being developed (7, de Vries *et al.*, unpublished data). These tests use bacterially expressed proteins as antigen and will hopefully avoid some of the problems of false-positive results due to reactivity of equine serum with contaminating cell culture-derived proteins (10).

TREATMENT

There is no specific treatment for acute infection with EAV. Most horses make an uneventful recovery and are resistant to clinical disease for perhaps their lifetime. In severe cases, treatment is symptomatic and good nursing care, especially in young horses, may be beneficial. In the stallion, care should be taken to minimize the severity and duration of pyrexia, which can result in a temporary decrease in fertility. Non-steroidal anti-inflammatory drugs are useful for alleviating pyrexia and a diuretic may help to control oedema (44). There is, at present, no treatment for persistent infection except for castration. The dependence on testosterone for the maintenance of persistent infection has some interesting treatment potential, but must await further research.

VACCINATION

There is no officially approved vaccine preparation available on the European continent. Within the USA, a modified live vaccine (ARVAC, Fort Dodge Laboratories) is available (43). Use of this vaccine has been instrumental in controlling the spread of EAV within the Throughbred populations of New York State and Kentucky (44). Stallions originally seronegative are vaccinated yearly with the live-attenuated vaccine. Seronegative mares to be bred by virus shedding stallions are also vaccinated no less than 3 weeks prior to breeding. No vaccinated stallion has shed virus in semen after vaccination or has become persistently infected (44, E. Dubovi, New York State Veterinary Diagnostic Laboratory, personal communication). It is unlikely that the modified live vaccine will become available in the EU due to stringent and expensive licensing requirements.

An inactivated, whole virus vaccine (ARTERVAC, also manufactured by Fort Dodge Laboratories) is also available. Since the use of the vaccine is limited and has recently been implemented (in Great Britain; 23), little is known about its efficacy in protecting against disease at times beyond 14 days post vaccination. It is also unknown whether vaccination with ARTERVAC protects against the development of persistent infection or abortion.

PREVENTION

In the past, little attention has been paid to EAV infections in Europe and no specific control measures have been adopted. Any successful control programme for EAV has to include the identification of persistently infected stallions and specific measures to prevent the lateral spread of EAV through the venereal infection of mares. All breeding stallions should be tested prior to the breeding season. Stallions which shed vi-

rus will be seropositive, but not all seropositive stallions will be virus shedders. If a stallion is found to be persistently infected, it should not be used for breeding purposes or be bred only to mares already seropositive either through natural infection or vaccination. While the seropositive status of mares will provide protection from disease after exposure to virus contaminated semen, some limited viral replication will occur (33). Because of this, mares bred to a seropositive stallion by natural service or through artificial insemination should be isolated from seronegative horses for a period of 3 weeks.

Vaccination of colts at 6 to 8 months of age, i.e. after maternal antibody has waned and before puberty, may also prevent the establishment of persistent infection after natural exposure. Studies in Japan, in which a formalin-inactivated vaccine preparation was used, indicated that vaccination prevented the establishment of persistence in challenged animals (18). There is no way to differentiate between a titre due to vaccination and a titre due to natural infection, so it is important that seronegative status prior to vaccination be documented if international movement of the horse is likely. As it appears that persistently infected animals serve as the initial source of virus in many of the sporadic EVA outbreaks reported, preventive vaccination may eventually allow the elimination of the virus from the equine population.

Current EU regulations require seronegative status or, if seropositive, negative virus isolation results from sperm of all stallions present in a breeding or artificial insemination facility involved in the intercommunity trade in semen (38A). If seropositive and not shedding virus, the stallion must be tested yearly to confirm the virus negative status. For owners with seropositive, virus shedding stallions, this represents a great economic burden. Control of the spread of EAV requires a cooperative effort on the part of all parties involved in the equine reproduction industry. While EAV has not been a significant problem in the past, evidence suggests that it may become so in the future. The percentage of seropositive horses in Germany has risen from 1.8% in 1987 to around 20% in 1995 (17). This has been accompanied by an increase in the observation of clinical illness consistent with EVA, which has been confirmed in only a few cases (17). The real extent of losses due to morbidity or abortion caused by EAV is probably underestimated because testing for EAV has rarely been done. This is especially relevant for the diagnosis of EAV-related abortions as there are no pathognomonic gross lesions and histopathological lesions, if present, are often subtle and thus overlooked as non-specific.

A coherent, pan-national strategy to deal with the EAV situation has not yet emerged within the EU or within the European equine industry. Successful control measures in the USA have involved extensive testing as well as vaccination of seronegative stallions and of seronegative mares bred to virus shedding stallions (44). Until a vaccine becomes available, good management to prevent the lateral spread of virus from bred mares to other susceptible horses is fundamental to control the further spread of EAV among the equine population.

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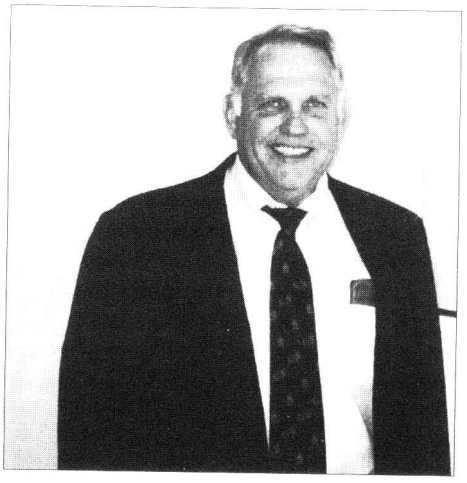

HONORARY DEGREE NIELS C. PEDERSEN

The Editorial Board is proud to announce that one of the members of the Consultant Editorial Board, Niels C. Pedersen DVM PhD, has received a honorary degree of the Utrecht University, Faculty of Veterinary Medicine. The presentation took place on May 9, 1996 in Utrecht, the Netherlands. Pedersen is an authority on the domain of feline infectious diseases.