Prevalence of morbilliviruses among pinniped and cetacean species

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Summary: Since 1987, morbillivirus infections have caused serious disease outbreaks with high mortality among aquatic mammals. Baikal seals (Phoca sibirica) in Siberia were involved in an outbreak caused by a virus closely related to canine distemper virus (CDV) in 1987. Harbour seals (Phoca vitulina) and grey seals (Halichoerus grypus) in north-western Europe were struck by a newly recognised morbillivirus of seals (PDV1). A serological survey has indicated that these morbillivirus infections frequently occur among several pinniped species.

Besides pinnipeds, the presence of morbillivirus infections among cetaceans, including whales, dolphins and porpoises, has been demonstrated since the outbreak of PDV among seals in north-western Europe. Morbillivirus was isolated from several stranded harbour porpoises (Phocoena phocoena). This virus proved to be very similar to a virus which was isolated during a disease outbreak with high mortality among striped dolphins (Stenella coeruleoalba) in the Mediterranean area. The viruses isolated from these cetacean species were quite different from the viruses isolated from the seals. They proved more related to the ruminant morbilliviruses, peste des petits ruminants virus and rinderpest virus.

The potential transmission of the dolphin morbillivirus to the endangered population of the Mediterranean monk seal (Monachus monachus) has been considered. Studies are presently being conducted into the possibility of inducing protection against morbillivirus infection in this species by vaccination with an immune stimulating complex (ISCOM) preparation based on CDV.


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Morbillivirus infection in pinniped species

Until 1988, the morbillivirus genus consisted of four known members: measles virus (MV), rinderpest virus (RPV), peste des petits ruminants virus (PPRV) and canine distemper virus (CDV), which infect humans, large ruminants, small ruminants and dogs, respectively (5). In 1988, the first evidence of morbillivirus infection in marine mammals was found in north-western Europe, where approximately 17,000 harbour seals (Phoca vitulina) died after infection with a virus which was named phocid distemper virus 1 (PDV1). The clinical symptoms resembled those of distemper in dogs; severe pneumonia and respiratory distress were most commonly observed. Although other seal species, such as the grey seal (Halichoerus grypus), were also infected during the outbreak, they did not develop serious disease to the same extent as the harbour seal (6). In 1987, a similar outbreak had been observed among Baikal seals (Phoca sibirica) in Lake Baikal in Siberia. In collaboration with scientists from the Limnological Institute in Irkutsk, the authors isolated a morbillivirus from a Baikal seal which had died after developing characteristic symptoms. This virus was named phocid distemper virus 2 (PDV2) (7). At that time, it was postulated that the virus might have been transmitted from Lake Baikal, by terrestrial animals or birds, to the seal population in Europe. However, on the basis of several characteristics, PDV2 was shown to be very similar if not identical to CDV, whereas PDV1 proved to be a newly-discovered morbillivirus (11). In an attempt to determine the origin and the prevalence of the virus in the past, and possible patterns of spread of morbilliviruses among marine mammals, several serum samples collected prior to the respective outbreaks were tested for the presence of morbillivirus-specific antibodies. Thus Dietz and colleagues found evidence for a previous morbillivirus infection in ringed seals (Phoca hispida) and harp seals (Phoca groenlandica) in Greenland (2). In this case, the specificity of the antibodies was not precisely determined. In 1984, 1985 and 1986, seven (10%) of seventy harbour seal sera from Europe were shown to contain morbillivirus-specific antibodies (8). Further investigations showed that, in conjunction with the outbreak of PDV1, the specificity of these antibodies changed from more CDV-specific to more PDV1-specific (unpublished findings). Bengston and colleagues also described the prevalence of CDV-like antibodies in crab eater seals (Lobodon carcinophagus) and leopard seals (Hydrurga leptonyx) in the Antarctic, and discussed a possible relationship between the severe pneumonia reported in 1955 and the outbreaks in 1987 and 1988 (1). Further evidence for a morbillivirus infection without direct relationship to the 1987 and 1988 outbreaks was found in serum from an Alaskan harbour seal sampled in 1984. It can be concluded from these data that morbilliviruses were present among pinniped species before 1988, although it was not until 1987 in Lake Baikal and 1988 in north-western Europe that severe disease and mass mortality among pinniped species could be directly related to morbillivirus infection.

Morbillivirus infection in cetacean species

In addition to Baikal and harbour seals, evidence for morbillivirus infection was found in harbour porpoises (Phocoena phocoena) which stranded on the Irish coast in 1988 (4). Although inclusion bodies suggestive of morbillivirus infection could be identified in these animals, a connection between disease and infection could not be proven. However, in 1990, another cetacean species, the Mediterranean striped dolphin (Stenella coeruleoalba), suffered from disease and mortality caused by a morbillivirus, which eventually led to the death of more than one thousand animals. This outbreak began in Spanish waters in 1990 and spread to France, the Strait of Gibraltar and Italy, where cases were first reported in 1991. Domingo and colleagues investigated organ
material of most stranded animals by immune histochemical assays and found evidence of morbillivirus infection in the majority of the animals (3). At present, there is evidence for the prevalence of morbillivirus infection in the harbour porpoise, the white beaked dolphin (*Lagenorhynchus albirostris*) and the striped dolphin. Preliminary data on morbillivirus isolates from dolphins and porpoises indicate a high degree of similarity between the viruses of these respective cetacean species, and a considerable difference from both PDV1 and CDV (9).

**Vaccination against morbillivirus infection**

To prevent morbillivirus infection in seals and protect them against lethal disease caused by such infections, a vaccination experiment was conducted in harbour seals in 1988 (10). In the past, morbillivirus vaccines had not always been successful in inducing immunity in their respective host species. Inactivated morbillivirus vaccines, in particular, failed to induce complete protection, and were also ineffective against infection with the homologous virus. Live vaccines are known to be quite effective in inducing at least partial cross-protection against infection with heterologous morbilliviruses but, in the past, such vaccines have been shown to have dangerous side-effects on wildlife species. To prevent these problems, a subunit vaccine exposing both the fusion (F) and the haemagglutinin (H) protein of morbilliviruses on a micellar structure – the immunostimulating complex (ISCOM) matrix – was tested for its efficacy in inducing protection against morbillivirus infection. Thus ISCOMs exposing the F and H protein of CDV or MV were successfully used to induce protection against CDV infection in dogs (13). Because the virus isolated from harbour seals in 1988 most closely resembled CDV, it was decided to test this and another inactivated CDV vaccine for their efficacy in protecting harbour seals against PDV1 infection. This experiment resulted in protection of the vaccinated animals from disease symptoms, whereas the non-vaccinated animals displayed a distemper-like disease before dying within eighteen days after challenge with PDV1 (10). However, it should be noted that vaccination of harbour seals with this heterologous CDV vaccine may still allow infection with PDV1 accompanied by mild respiratory symptoms (12).

**Conclusions**

Since 1988, a variety of pinniped and cetacean species have been shown to be susceptible to infection with morbilliviruses, leading to dramatic population losses. Based on present knowledge, pinniped and cetacean species seem to maintain different clusters of morbilliviruses. Since three marine mammal species have already suffered substantial losses following introduction of morbillivirus in naive populations, there is a possibility that already endangered marine mammal species may be threatened with extinction if infected with one of these circulating or newly-emerging morbilliviruses. It would therefore be useful to have access to a vaccine which could protect these animals from lethal infection. Two candidate CDV vaccines were successfully tested for efficacy in inducing protection against PDV infection in harbour seals, and a similar experiment is now underway in Mediterranean monk seals (*Monachus monachus*). As these animals may not be challenged, the efficacy of the CDV-ISCOM vaccine in eliciting protective immunity against morbillivirus infection is now being tested in Hawaiian monk seals (*Monachus schauinslandi*) by serological and other immunological assays. If indeed the vaccine does prove to be protective in these species, vaccination of wild or captive animals could be considered within the framework of conservation strategies (9).

Résumé : Depuis 1987, des infections à morbillivirus ont été à l'origine d'épisodes graves, associés à une mortalité élevée, chez les mammifères aquatiques. En 1987, des phoques de l'espèce Phoca sibirica, en Sibérie, ont été touchés par un virus étroitement apparenté au virus de la maladie de Carré. Dans le nord-ouest de l'Europe, des phoques veaux-marins (Phoca vitulina) et des phoques gris (Halichoerus grypus) ont été atteints par un morbillivirus nouvellement identifié chez les phoques (PDV1). Une enquête sérologique a montré que ces infections à morbillivirus sont fréquentes chez plusieurs espèces de pinnipèdes.

Depuis l'épisode à PDV qui a touché des phoques dans le nord-ouest de l'Europe, des infections à morbillivirus ont été démontrées chez des cétacés dont des baleines, des dauphins et des marsouins. Des morbillivirus ont été isolés chez plusieurs marsouins communs (Phocoena phocoena). Ce virus s'est révélé très proche de celui qui a été identifié lors d'épisodes mortels chez des dauphins bleus et blancs (Stenella coeruleoalba), dans la région méditerranéenne. Les virus isolés chez ces espèces de cétacés étaient assez différents de ceux qui avaient été trouvés chez les phoques. Ils se sont révélés plus proches des morbillivirus des ruminants, tels que ceux de la peste des petits ruminants et de la peste bovine.

On peut craindre le risque de transmission des morbillivirus des dauphins à la population méditerranéenne des phoques moines (Monachus monachus) dont la survie est menacée. Des études sont en cours sur la possibilité de protéger ces espèces contre les infections à morbillivirus, grâce à un complexe immunostimulant («ISCOM») préparé à partir du virus de la maladie de Carré.

MOTS-CLÉS : Dauphin - Mammifères aquatiques - Marsouin - Morbillivirus - Phoque,


Resumen: Desde 1987, las infecciones por morbillivirus provocan graves brotes de enfermedad con alta mortalidad en las poblaciones de mamíferos acuáticos. En Siberia, las focas del lago Baikal (Phoca sibirica) fueron víctimas, en 1987, de un brote debido a un virus íntimamente relacionado con el virus del moquillo canino. En el noroeste de Europa, las focas comunes (Phoca vitulina) y las focas grises (Halichoerus grypus) fueron afectadas por un morbillivirus de las focas identificado recientemente (PDV1). Una encuesta serológica reveló que estas infecciones por morbillivirus son frecuentes en varias especies de pinnípedos.

Desde el brote que afectó a las focas del noroeste de Europa, se ha demostrado la presencia de infecciones por morbillivirus, no sólo entre los pinnípedos sino también entre los cetáceos, como ballenas, delfines y marsupas. En varias marsupas comunes (Phocoena phocoena) se aisló un morbillivirus
que resultó ser muy similar a un virus aislado durante un brote de enfermedad que causó la muerte de numerosos delfines rayados (Stenella coeruleoalba) en la zona del Mediterráneo. Los virus aislados en estas especies de cetáceos eran muy diferentes de los virus aislados en las focas y más parecidos a los morbillivirus de los rumiantes, como el virus de la peste de los pequeños rumiantes y el virus de la peste bovina.

Se ha considerado el posible riesgo de transmisión del morbillivirus de los delfines a la especie amenazada de extinción de focas frailes del Mediterráneo (Monachus monachus). Se estudia actualmente la posibilidad de proteger a esta especie contra las infecciones por morbillivirus con un complejo inmunoestimulante («ISCOM») preparado a partir del virus del moquillo canino.

PALABRAS CLAVE: Delfín – Foca – Mamíferos acuáticos – Marsopa – Morbillivirus.

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REFERENCES


