Malignant Catarrhal Fever

Malignant Catarrh,
Malignant Head Catarrh,
Gangrenous Coryza,
Catarrhal Fever,
Snotsiekte

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Importance

Malignant catarrhal fever (MCF) is a serious viral disease that can affect many species in the order Artiodactyla (even-toed ungulates) including cattle, bison, water buffalo, exotic ruminants, deer and other cervids, and pigs. At least ten MCF viruses have been recognized, including two well-known agents carried by sheep and wildebeest and additional viruses normally found in goats or exotic ungulates. Each virus is highly adapted to its usual host, and is usually carried asymptomatically in this reservoir; however, it can cause serious illness in other species. There is no effective treatment and case fatality rates are very high.

MCF can be an unpredictable disease. While the causative viruses are very common in their reservoir hosts, which remain infected for life, susceptible incidental hosts may or may not become ill on exposure to these animals. Outbreaks occur regularly in some areas, particularly in regions of Africa where cattle are seasonally exposed to the wildebeest virus at times of peak replication. In other parts of the world, clinical cases tend to be sporadic, and may develop unexpectedly in animals that had previously contacted reservoir hosts without consequences. Outside Africa, MCF is a particularly significant issue for the bison industry, farmed cervids, Bali cattle and zoos, and most cases are caused by the sheep-associated virus. The only reliable methods of control, at present, are to separate susceptible species from carriers or to breed virus-free reservoir hosts.

Etiology

Malignant catarrhal fever is caused by viruses in the genus *Macavirus* of the family Herpesviridae (subfamily Gammaherpesvirinae). MCF viruses are usually named after their reservoir hosts. The Alcelaphinae/Hippotraginae group of MCF viruses contains alcelaphine herpesvirus 1 (AlHV-1), AlHV-2, hippotragine herpesvirus 1 (HiHV-1) and MCFV-oryx. HiHV-1 and MCFV-oryx appear to be very similar and might be the same virus. The Caprinae group includes ovine herpesvirus 2 (OvHV-2), caprine herpesvirus 2 (CpHV-2), MCF virus-white tailed deer (MCFV-WTD), MCFV-ibex, MCFV-muskox and MCFV-aoudad. It should be noted that MCFV-WTD is an anomaly: this virus was named after the affected species rather than the reservoir host, which was not known at the time. Recent reports suggest that MCFV-WTD is probably carried in goats, and some authors have proposed changing its name to caprine herpesvirus 3 (CpHV-3). Two additional viruses, which seem to share a high degree of genetic similarity, were recently described in chamois and tentatively named Rupicapra rupicapra gammaherpesvirus 1 (RrupGHV-1) and Rupicapra pyrenaica gammaherpesvirus 1 (RpHV-1).

The two most important viruses are OvHV-2, which causes sheep-associated MCF, and AlHV-1, which causes the wildebeest-associated form of this disease. Other viruses known to be pathogenic include CpHV-2, MCFV-WTD, MCFV-ibex and AlHV-2. No illness has been associated yet with MCFV-muskox, MCFV-oryx, Hi-HV-1, MCFV-aoudad or the virus(es) found in chamois. Nevertheless, these viruses are also thought to be capable of causing MCF.

Species Affected

MCF viruses are usually carried asymptomatically in their reservoir hosts. Wildebeest (*Connochaetes* spp.) are the reservoir hosts for AlHV-1. The blue wildebeest (*Connochaetes taurinus*) is the major host, but this virus also occurs in black wildebeest (*Connochaetes gnou*). AlHV-2 has been found in hartebeest (*Alcelaphus buselaphus*) and two species of topi, *Damaliscus korrigum* and *D. lunatu.* Domesticated sheep (*Ovis aries*) are the most important reservoir hosts for OvHV-2, but at least some of their wild relatives including Dall's sheep (*Ovis dalli*), mouflon (*Ovis orientalis*) and bighorn sheep (*Ovis canadensis*) are also carriers, and asymptomatic infections have been reported in goats. Goats are the reservoir hosts for CpHV-2. They are also thought to carry MCFV-WTD. MCFV-ibex, MCFV-muskox, MCFV-oryx, HiHV-1, and MCFV-aoudad have been found in asymptomatic Nubian ibex (*Capra nubiana*), muskox (*Ovibos moschatus*), gemsbok/ South African oryx (*Oryx gazella*), roan antelope

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(*Hippotragus equinus*) and aoudads (*Ammotragus lervia*), respectively. RrupGHV-1 was described in Alpine chamois (*Rupicapra rupicapra*) and RpHV-1 in Pyrenean chamois (*Rupicapra pyrenaica pyrenaica*).

Clinical cases usually occur in incidental hosts, mainly members of the order Artiodactyla (even-toed ungulates). Commonly affected animals include cattle, bison (*Bison* sp.), water buffalo (*Bubalus bubalis*), other ruminants and cervids, but illnesses have been reported in other species such as giraffes and pigs. In unusual cases, MCF viruses might be able to cause disease in their reservoir hosts; rare clinical cases appeared to be associated with OvHV-2 infections in a few goats, at least two naturally infected lambs, captive Stone's sheep (*Ovis dalli stonei*) and Barbary sheep (*Ammotragus lervia*), and a free-living bighorn sheep. MCF-like disease was also seen in experimentally infected sheep that had been given high doses of OvHV-2.

Susceptibility to individual MCF viruses differs between species.

Incidental hosts susceptible to AlHV-1

Clinical cases caused by AlHV-1 occur frequently in European breeds of cattle (*Bos taurus*, *Bos indicus*). They have also been reported in some other species such as Bali cattle/ banteng (*Bos javanicus*), bison, water buffalo and African buffalo (*Syncerus caffer*). Exposure to wildebeest is limited, and whether some animals can be affected by AlHV-1 is unknown. However, it has been suggested that most ruminants and cervids other than antelope of the subfamilies Alcelaphinae and Hippotraginae should be considered susceptible. Rabbits and hamsters can be infected experimentally.

Incidental hosts susceptible to OvHV-2

OvHV-2 can cause MCF in a wide range of hosts. American bison (*Bison bison*), Bali cattle/ banteng and certain cervids such as Père David's deer (*Elaphurus davidianus*), white-tailed deer (*Odocoileus virginianus*), axis deer (*Axis axis*) and sika deer (*Cervus nippon*) are reported to be especially susceptible to this virus. Clinical cases have also been seen in other cervids (e.g., roe deer, *Capreolus capreolus*; moose, *Alces alces*; red deer, *Cervus elaphus*; elk, *Cervus canadensis*), water buffalo, pigs, goats, and various exotic zoo ungulates including European bison (*Bison bonasus*), Nile lechwe (*Kobus megaceros*), African buffalo and giraffes. Fallow deer (*Dama dama*) seem to be relatively resistant. While OvHV-2 does occasionally affect *Bos taurus* and *Bos indicus* cattle, their susceptibility also appears to be low. Unusually, one clinical case thought to be caused by OvHV-1 and several asymptomatic infections occurred in horses (order Perissodactyla) on a farm where these animals shared their feed with goats. Rabbits and hamsters can be infected experimentally.

Incidental hosts susceptible to other viruses

Clinical cases caused by CpHV-2 have been seen in cervids including moose, roe deer, sika deer, white-tailed deer, pronghorn (*Antilocapra americana*) and pudu (*Pudu pudu*), as well as water buffalo. MCFV-WTD has been found in sick white-tailed deer, red brocket deer (*Mazama americana*) and reindeer (*Rangifer tarandus*), and might affect cervids in general. MCFV-ibex was associated with illnesses in several bongo antelope (*Tragelaphus eurycerос*) and an anoa, and a virus resembling AlHV-2- was found in sick Barbary red deer (*Cervus elaphus barbarus*). AlHV-2 also caused clinical signs in some experimentally infected cattle and American bison.

Zoonotic potential

There is no evidence that any of the MCF viruses can infect humans.

Geographic Distribution

AlHV-1-associated disease can seen in zoos worldwide and in areas of sub-Saharan Africa that contain wild wildebeest. This virus is reported to be the most important MCF virus in some parts of Africa, although OvHV-2-associated disease can also be seen.

OvHV-2 is the major cause of MCF in animals outside Africa. Sheep-associated MCF is common among Bali cattle in Indonesia; however, cattle are infrequently affected in countries where *Bos taurus* and *Bos indicus* are the predominant species. OvHV-2 is a serious concern in countries with bison and cervid farms, as these species are very susceptible. It is also important in zoos and wildlife parks, where small ruminants and their wild relatives may be kept in petting zoos or exhibits.

Clinical cases from other MCF viruses have generally been reported in zoos and other facilities that house diverse wildlife in close proximity.

Transmission

MCF viruses establish lifelong, latent infections in their reservoir hosts. In wildebeest, AlHV-1 occurs in both cell-free and cell-associated forms. Cell-free AlHV-1 is infectious but cell-associated virus is transmitted only rarely to other animals. Wildebeest shed cell-free virus in nasal and ocular secretions for a short period after they become infected. Most animals are thought to acquire the virus either *in utero* or soon after birth. Calves can transmit the virus to each other either via direct contact or in aerosols. Contamination of pastures may also contribute to transmission. Virus shedding usually peaks in 3-4 month-old animals. AlHV-1 is mainly cell-associated after the age of 6 months, and these wildebeest generally shed little virus. However, cell-free virus may occasionally be found in the nasal secretions of older animals that are stressed or given corticosteroids.

OvHV-2 is likewise excreted mainly from the upper respiratory tract, especially in nasal secretions. Virus shedding is reported to occur intermittently for brief periods,

which may be as short as 24 hours. Transmission to lambs *in utero* or via milk is thought to be possible but uncommon. Viral nucleic acids have also been detected in the semen of rams though the significance of this finding is still unclear. Sheep of all ages may occasionally transmit OvHV-2; however, one study found that shedding peaks in 6-9 month-old animals. CpHV-2 transmission in goats seems to resemble that of OvHV-2. In one herd of goats, there was no evidence of infection at birth and viral DNA was first detected at 3 months of age. Adult goats also became infected readily when exposed to a CpHV-2-infected herd. There is little or no information about the transmission of most other MCF viruses in their reservoirs.

Incidental hosts become infected through direct or indirect contact with the reservoir hosts. Inhalation is thought to be the primary route, but ingestion may also be possible. Contact with AlHV-1 in wildebeest placentas was suggested to account for some cases, but the amount of virus in the placenta seems to be very low, and this route is still speculative. Although outbreaks often occur after close contact with carriers, MCF viruses can sometimes travel significant distances in aerosols. Wildebeest-associated MCF has been reported when animals were separated from wildebeest by at least 100 meters; sheep-associated MCF when cattle were 70 meters from any sheep; and CpHV-2-associated MCF when sika deer were 1 km from goats. One outbreak of sheep-associated MCF occurred in a bison herd located 5 km from a lamb feedlot; however, the risk appears to vary with distance, and under the climatic conditions in Canada, most incidents occur when bison are within 1 km of sheep.

Incidental hosts are generally regarded as dead end hosts for MCF viruses. Although horizontal transmission was a possibility in a few instances, and OvHV-2 nucleic acids have been found in some secretions and excretions (e.g., nasal secretions of water buffalo, semen of pigs), there is no definitive evidence that these animals are capable of infecting others. In addition, epidemiological evidence suggests that, if any transmission occurs, it is minimal or insignificant. However, AlHV-1 and OvHV-2 can both cross the placenta to infect the fetus in cattle, and OvHV-2 was found in the spleen of a water buffalo fetus.

MCF viruses can be transmitted on fomites, but they do not remain viable for long periods in the environment. Under humid conditions, which enhance the survival of enveloped viruses, cell-free AlHV-1 was found to persist for more than 13 days. Conversely, MCF viruses are reported to lose their infectivity within 3 hours under hot, dry conditions. Cell-associated AlHV-1 is very fragile and cannot be recovered after 72 hours.

Disinfection

Many common disinfectants can inactivate MCF viruses. If heavy organic debris is present, the World Organization for Animal Health (OIE) recommends 3% sodium hypochlorite.

Incubation Period

The incubation period may vary with the virus, host and other factors, and is incompletely understood. It is thought to range from 2 weeks to a few months in most cases; however, there are reports of cattle becoming ill as late as 9 months after exposure. In one outbreak in subclinically infected bison, clinical cases tended to occur 3-14 days after the animals were stressed by handling.

Clinical Signs

Incidental hosts

Malignant catarrhal fever can appear as a peracute illness, with few clinical signs before death, or with a more prolonged course where the animal survives for a week or more. Peracute MCF occurs most often in highly susceptible hosts such as some cervids, with death sometimes preceded by 12-24 hours of depression, weakness, diarrhea or dysentery. The occurrence of mild or inapparent infections is suggested by the presence of antibodies and/or nucleic acids in asymptomatic cattle, bison, cervids and pigs.

Most clinical cases have been described in cattle. In addition to nonspecific signs of illness, such as high fever, depression, anorexia and a drop in milk production, common signs in this species include profuse oculonasal discharge and bilateral corneal opacity, which usually starts at the corneoscleral junction and progresses inward (centripetally). Additional ocular signs (e.g., anterior uveitis, corneal ulcers) may be found on examination of the eye. The oculonasal discharge is initially serous, but later becomes profuse and mucopurulent. The muzzle and nares are usually encrusted, and dyspnea or open-mouthed breathing may be seen. The oral mucosa is often hyperemic and may contain areas of necrosis and erosions. Oral discomfort can cause excess salivation. The superficial lymph nodes are often markedly enlarged, the joints are sometimes swollen, and neurological signs are possible, especially in the terminal stages. Diarrhea, hemorrhagic gastroenteritis or hematuria may also be seen, although these signs are less prevalent than in bison and deer. Sometimes cattle have skin lesions such as erythema, ulcers and hardened scabs, which are particularly common on the perineum, udder and teats. There is at least one report where MCF-associated skin lesions were the main syndrome in cattle. Animals occasionally recover from MCF bur most clinical cases are fatal. Surviving cattle may have sequelae such as persistent eye lesions or reduced productivity. Prolonged (chronic) cases and recrudescent disease have been reported.

MCF generally appears similar in other species but may differ in some aspects. Corneal opacity is reported to be inconsistent in water buffalo, while mild to moderate conjunctivitis seems to be common. American bison often die rapidly without developing purulent rhinitis or corneal opacity, although some animals have typical nasal, ocular, gastrointestinal and/or neurological signs. Hematuria and hemorrhagic enteritis are more common in this species than

cattle, and the lymph nodes are usually less markedly enlarged. Bison often attempt to mask the clinical signs until they are near death. In the last stage of the disease, they frequently develop an edematous band at the corneoscleral junction (however, this lesion is difficult to recognize in live animals). Inhalation pneumonia is also common terminally, and some sick bison may be attacked by herdmates, resulting in trauma.

Malignant catarrhal fever is often peracute in highly susceptible species of deer. Less susceptible cervids can have a more prolonged disease course, with some animals surviving for up to 3 weeks. Hemorrhagic diarrhea and bloody urine are reported to be more common than in cattle, and nasal discharge, crusting of the muzzle and corneal opacity tend to be less prominent. Unusually, skin lesions were the primary complaint in some white-tailed deer infected with CpHV-2. The clinical signs in these animals included widespread alopecia; thickening, crusting, hyperkeratosis and focal ulcerations of the skin; weight loss; impaired vision; and sloughing of the hoof walls in some individuals. Similarly, extensive alopecia, weight loss and diarrhea were the primary signs in some CpHV-2-infected sika deer. In another outbreak caused by this virus, several sika deer became lame as the result of lymphoid cell infiltration of the subcutaneous tissue around the tendons. Abnormal behavior, apathy and incoordination were prominent in some free-living moose and roe deer with MCF, and one captive sika deer infected with CpHV-1 developed seizures but had no other clinical signs before it was euthanized.

Fever and dyspnea are reported to be the most consistent signs in pigs with acute MCF. Additional signs seen in some outbreaks included crusting rhinitis or foul-smelling nasal discharges, erosions on the nasal and oral mucosa, corneal edema, uveitis, hematuria, reproductive losses (abortions, stillbirths and smaller than normal litters), reddened foci on the skin and neurological signs. Sometimes only pregnant animals were affected. The course of the disease in pigs usually seems to be acute or peracute, but chronic illnesses lasting for several weeks have been seen. Experimentally infected one-week-old piglets became febrile and depressed, with anorexia, adipsia, skin rashes and seizures, but nasal and ocular discharges, corneal opacity and diarrhea were absent. It is possible that these animals were euthanized before the latter signs could develop.

A few clinical cases have been documented in other animals. Possible MCF was reported in an OvHV-2 infected alpaca, which was depressed, dehydrated, inappetent and emaciated. Unusually, OvHV-2 nucleic acids were found in a sick 6-month-old foal and asymptomatic adult horses on a farm in Brazil. The foal had neurological signs and severe dyspnea, which was rapidly progressive and fatal, and the histopathological lesions were consistent with MCF.

Reservoir hosts

The reservoir hosts for MCF viruses do not normally show any signs of illness. Rare clinical cases attributed to OvHV-2 are thought to result from unusually high virus replication. One naturally-occurring case in a 6-month-old lamb was characterized mainly by progressive respiratory distress and poor condition. A 4-month-old lamb in a different herd had similar signs, with debilitation and respiratory signs that included coughing, fever and nasal discharge. Three OvHV-2-infected goats were febrile, with neurological signs. One of them also had diarrhea and bilateral corneal opacity. Sheep inoculated experimentally with high doses of OvHV-2 developed a fever and mucopurulent nasal discharge but continued to eat and drink normally, and recovered. Preliminary evidence suggests that systemic necrotizing vasculitis (idiopathic polyarteritis) in sheep might be linked to OvHV-2, but this remains to be proven.

A few suspected cases occurred in free-living or captive wild small ruminants. Two Stone's sheep (*Ovis dalli stonei*) in a zoo were thought to be affected by OvHV-1. One died unexpectedly with few clinical signs; the other had neurological signs including hind limb weakness, unusual aggression toward humans, and seizures. A wild bighorn sheep infected with OvHV-2 was in poor condition, with muscle atrophy, marked weight loss and skin lesions of bilaterally symmetric alopecia with hyperpigmentation and crusting on the face, trunk, distal limbs, perineum and tail. This animal had concurrent bronchointerstitial pneumonia attributed to lungworms, which could have contributed to its debilitation, but OvHV-2 nucleic acids were associated with the skin lesions.

There are currently no reports of illnesses attributed to other MCF viruses, including AlHCV-1, in their reservoir hosts.

Post Mortem Lesions

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Malignant catarrhal fever is characterized by inflammation and epithelial necrosis with lympho-proliferation, infiltration of nonlymphoid tissues by lymphoid cells, and vasculitis.

Incidental hosts

Animals that die suddenly may have few gross lesions; however, hemorrhagic enterocolitis can be seen in some cases. If the disease course is longer, the carcass may be dehydrated, emaciated or normal. As in live animals, external lesions may include diffuse or focal bilateral corneal opacity; serous, mucopurulent or purulent nasal discharge; hyperemia, edema and small focal erosions or ulcers on the nasal mucosa; hyperemia and multifocal or diffuse areas of necrosis and ulcers in the oral cavity; and skin lesions. The lymph nodes are generally enlarged, and are especially prominent in cattle. They tend not to be as swollen in bison or deer. On cut surface, they may be firm and white, hemorrhagic or necrotic.

Petechiae or ecchymoses are frequently found on the serosa of the internal organs, and prominent raised white foci or nodules, 1-5 mm in diameter, may be seen in some tissues. Mucosal erosions, punctate or larger ulcers, and hemorrhages can occur throughout the gastrointestinal tract. In severe cases, the intestinal contents can be hemorrhagic. Hemorrhagic colitis or enterocolitis is especially common in cervids and bison. The mucosa of the urinary bladder is often hyperemic and edematous, with ecchymotic hemorrhages. Catarrhal exudates and erosions may be detected in the upper respiratory tract. In more prolonged cases in cattle, the small arteries in multiple organs can be very prominent and tortuous, with thickened walls. Unique features in three periparturient bongos included necrotizing cholangiohepatitis and myocarditis, together with more typical MCF lesions. Cardiac lesions (epicarditis, myocarditis) were also reported to be common in some water buffalo. Bison that die with few clinical signs may have advanced lesions on necropsy.

Sick reservoir hosts

No striking gross lesions were found in one lamb thought to be affected by OvHV-2, although some organs including the lungs were diffusely pale. (Arteritis was detected on histopathological examination.) Another lamb had gross lesions similar to those of cattle with MCF: enlarged lymph nodes, widespread evidence of vasculitis in the internal organs, and ulcers and minor hemorrhages in the abomasal and esophageal mucosa. Lesions associated with bronchointerstitial pneumonia were also found in this animal. Experimentally infected sheep that were euthanized had erosions and ulcers in the oral mucosa, pharynx and proximal esophagus, as well as edema and areas of consolidation in the lungs associated with bronchointerstitial pneumonia. Severe perirenal hemorrhages and multiple renal infarcts were seen in Stone's sheep thought to have MCF, together with petechial hemorrhages in multiple tissues, and serosanguinous to fibrinous effusion in some body cavities.

Diagnostic Tests

Sick incidental hosts

Malignant catarrhal fever is often suspected based on the microscopic lesions in the tissues at necropsy. Because some MCF viruses cannot be isolated, polymerase chain reaction (PCR) assays are often the method of choice for confirmation. Lymphoid tissues such as the spleen and lymph nodes are preferred for this test, but other tissues can also be used. Most PCR assays are designed to detect AlHV-1 and/or OvHV-2, but tests for other MCF viruses may be available. Epidemiological information (e.g., contact with sheep but not wildebeest) should guide the choice of assay.

Viruses in the Alcelaphinae/ Hippotraginae group (e.g., AlHV-1) can be isolated from the blood of live animals or from the lymph nodes, spleen and other affected tissues at necropsy. MCF viruses are inactivated quickly in dead animals, and samples should be taken as soon as possible. The most useful samples are collected immediately after euthanasia of a dying animal. The viability of the host cells must be maintained after sample collection, as the virus cannot be recovered from dead cells. AlHV-1 can be cultured in bovine thyroid cells or other susceptible cell lines, and it can be identified by immunofluorescence or immunocytochemistry. OvHV-2 and CpHV-2 have never been isolated from any animal, including their reservoir hosts.

Serological tests for MCF viruses include virus neutralization (VN), immunofluorescence or immunoperoxidase tests, ELISAs and immunoblotting. Although all of these tests are based on antigens from alcelaphine herpesviruses, which can be propagated *in vitro*, they also detect antibodies to other MCF viruses such as OvHV-2 and CpHV-2. However, they cannot distinguish reactivity to different viruses. In addition, the VN test is not useful in incidental hosts, which do not usually develop neutralizing antibodies. Serological tests are generally more valuable in sick cattle and bison than in highly susceptible species such as deer, which often die before antibodies develop. Cross-reactions with other herpesviruses (e.g., bovine herpesvirus-4) are possible, especially in tests that use polyclonal antibodies. Because healthy incidental hosts sometimes have antibodies to MCF viruses, serology should be used in conjunction with histopathology and clinical findings.

Sick reservoir hosts

It is difficult to prove a diagnosis of MCF in the reservoir host for a virus. Suggestive findings include histopathology consistent with MCF and the elimination of other possible causes for the illness. Some researchers have also supported the diagnosis by finding unusually high copy numbers of nucleic acids compared to inapparent carriers.

Asymptomatic reservoir hosts

Serology can be used to identify infected reservoir hosts. Seroconversion may take more than 4 weeks in animals that received a low dose of virus, and maternal antibodies can be a problem in young animals, such as lambs less than 4 months of age. All of the serological tests, including virus neutralization, can be used in wildebeest. However, VN is not useful for animals infected with the Caprinae group of MCF viruses (e.g., sheep and goats), as they do not have significant titers of neutralizing antibodies to alcelaphine herpesviruses.

Highly sensitive PCR assays are sometimes used to confirm the absence of infection in reservoir hosts, for instance when producing OvHV-2-free sheep. The peripheral blood leukocytes of sheep generally have enough OvHV-2 DNA to identify carriers, but this does not seem to be the case for all MCF reservoirs, such as oryx or black wildebeest. Goats may resemble sheep; nucleic acids of CpHV-2 were found by PCR in 85% of seropositive animals.

Cell-free AlHV-1 can be isolated from the nasal secretions and peripheral blood leukocytes of wildebeest

calves for a short period after they become infected. Cell-associated AlHV-1 can be recovered from wildebeest by culturing tissues.

Subclinical infections in incidental hosts

OvHV-2 DNA occurs at very low levels in subclinically infected bison and cattle, and it may not be detected readily by PCR. Serology can identify healthy incidental hosts that were exposed to MCF viruses.

Treatment

No specific antiviral therapy is available. Antibiotics to control secondary infections and supportive therapy may occasionally be helpful, but most affected animals die.

Control

Disease reporting

Veterinarians who encounter or suspect malignant catarrhal fever should follow their national and/or local guidelines for disease reporting. In the U.S., this disease is reportable in many states. State authorities should be consulted for more specific information.

Prevention

Malignant catarrhal fever is usually prevented by separating susceptible animals from sheep, goats, wildebeest or other reservoir hosts. The degree of susceptibility can influence separation requirements. For example, *Bos taurus* and *Bos indicus* cattle should not be allowed to come near wildebeest, but sheep-associated MCF is uncommon in these cattle, and there may be few or no losses if they contact sheep. The distance needed to prevent airborne transmission is uncertain. It is likely to be influenced by the number of reservoir hosts shedding viruses, the amount of virus they shed, and environmental conditions such as temperature and humidity, as well as the susceptibility of the incidental host. Some research has been done on OvHV-2 transmission to bison, and under the environmental conditions in Canada, most outbreaks tend to occur when sheep and bison are within one kilometer of each other. Fomites should be disinfected before contact with susceptible incidental hosts, and these animals should not be allowed on pastures where reservoir hosts have recently grazed. This is especially important near the time when wildebeest give birth.

In zoos and wild animal parks, control is complicated by the number of potentially susceptible species and MCF virus carriers, which are often poorly characterized. OvHV-2 and AlHV-1 are important concerns, but there also have been at least two incidents involving MCF virus transmission from Nubian ibex to bongo. Because it now appears that some captive-born wildebeest may not be infected with AlHV-1, it might be helpful to test these animals for antibodies before introducing them to a zoo. In some circumstances, the production of virus-free hosts for zoos or wildlife parks can also be considered. OvHV-2-free sheep and mouflon have been produced by early weaning, isolation and testing for virus. CpHV-2-free goats were generated by separating them from an infected herd at 7-10 days of age. Producing and maintaining virus-free hosts is generally not practical for ordinary commercial small ruminant herds.

To prevent further cases during an outbreak, susceptible animals should be separated immediately from the reservoir hosts or their environment. The current consensus is that sick animals do not need to be culled or separated, as transmission from them is unlikely or rare. Good husbandry, including reduced exposure to stressors, might help prevent serious illnesses in subclinically infected or mildly affected animals

Morbidity and Mortality

MCF viruses usually spread readily in their reservoir hosts and establish lifelong latent infections, resulting in a high prevalence of virus carriers. In wild wildebeest, there is an intensive period of virus transmission during the first few months of life, and almost all wild calves are thought to become infected by the age of 6 months. Virus transmission to incidental hosts often occurs during this time, and clinical cases in these animals are thought to be uncommon once all the wildebeest are older than 6 months. However, a second peak of disease has been identified in some African cattle when wildebeest calves are 8-10 months old. This peak was attributed to cattle becoming more susceptible to MCF at this time of year, due to factors such as rainy weather and poor grazing. Uninfected wildebeest were once thought to be rare or absent even in zoos. However, surveys of zoo animals have found some seronegative wildebeest, and in one recent study from France, all captive-born wildebeest at two of the sampled zoos were seronegative.

OvHV-2 is common in sheep, but most lambs in naturally infected flocks do not seem to become infected until they are at least 2 months old. While sheep of all ages may transmit OvHV-2, one study found that 6-9 month-old lambs shed the most virus. Outbreaks of sheep-associated MCF occur most often during lambing season, but the reason is still unclear. Some authors suggest that this phenomenon might be related to improved virus survival at cool temperatures, or seasonal variations in stock densities, rather than increased virus shedding at this time. According to some reports, certain flocks of sheep seem to be particularly associated with recurring OvHV-2 transmission to cattle.

There is limited research on other MCF virus reservoirs, but in one infected goat herd, 94% of the animals became infected by the age of 10 months. In this herd, CpHV-2 DNA was first detected in goat kids at 3 months of age, approximately 50% seroconverted by 7 months, and more than 80% had antibodies by 9 months. The prevalence of MCF viruses in wild sheep and goats is poorly understood, and may differ between species and populations. One study found that 95% of the animals in a group of wild Dall's sheep in Alaska were seropositive. Antibodies have also been found in some bighorn sheep, but at least one population of bighorn sheep had no evidence of infection. Seropositive

muskox appear to be common in North America and Norway, and many muskox calves in Norway are infected with MCFV-muskox by the age of 4 months.

Clinical cases are mainly reported in domesticated animals and captive wild species. However, it is likely that some cases in free-living wildlife are missed. The case fatality rate for MCF is very high in all species. It is estimated to average 80-90% in symptomatic cattle, reported to range from 75% to 100% in water buffalo, and may approach 100% in bison and deer. The morbidity rate varies, depending on the specific virus and host. In Africa, morbidity from wildebeest-associated MCF is estimated to be around 6-7% in most herds of cattle, but higher losses are also reported. Sheep-associated MCF in *Bos taurus* and *Bos indicus* cattle tends to be sporadic, often affecting just one to a few animals. The herd morbidity rate is typically less than 1%, though there have been reports of unusual outbreaks where this disease affected up to 16-50% of the exposed cattle. Farmed cervids and bison are more susceptible to OvHV-2. Morbidity can be as high as 50-100% in bison when they are in close contact with sheep, or stressed and crowded in feedlots. In the absence of such factors, some authors indicate that the usual morbidity rate in bison is around 4-10%.

MCF can be an unpredictable disease, and cases sometimes occur in animals that were exposed to carriers without incident for years. Significant numbers of healthy incidental hosts can be seropositive, with some studies reporting antibodies in up to 25-43% of healthy bison, cattle, cervids or pigs. Why animals do not always become ill on exposure to carriers is unclear, but stressors that increase virus shedding in the carrier and/or susceptibility in the incidental host, or environmental conditions (e.g., high humidity) that increase virus survival or concentrate the virus have been suggested as possible factors. Pregnant animals seemed to be more susceptible in some incidents, and genetic susceptibility to illness has been identified in bison. Younger animals also seem to be affected more often than older ones. What causes clinical cases in virus reservoirs is currently uncertain, but these illnesses seem to be rare and may be linked to unusually high virus replication.

Internet Resources

The Merck Veterinary Manual

World Organization for Animal Health (WOAH)

WOAH Manual of Diagnostic Tests and Vaccines for Terrestrial Animals

WOAH Terrestrial Animal Health Code

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