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FELINE RABIES
ABCD guidelines on prevention and management

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Virus properties

Rabies virus is a member of the *Rhabdoviridae* family, which includes more than 175 viruses of vertebrates, invertebrates and plants. Based on virion properties and serological relationships, four genera containing animal viruses have been recognised in the family. Rabies virus belongs to the genus *Lyssavirus*, together with European bat lyssaviruses (EBL) 1 and 2, and other African and Australian lyssaviruses. Each of these viruses can cause rabies-like disease in animals and humans. Many lyssaviruses use bats as reservoir hosts.

Rhabdovirions (rhabdovirus particles) consist of a cylindrically coiled, helical nucleocapsid enveloped by a lipoprotein membrane that carries prominent projections (peplomers). The cylindrical form of the nucleocapsid core gives the viruses their distinctive bullet or conical shape. It encloses the genome, a single molecule of linear, negative-sense, single-stranded RNA, 11–15 kb in size. Rhabdovirions generally contain five proteins. Among them, the glycoprotein (G), which the peplomers are comprised of, carries neutralising epitopes, the targets of vaccine-induced immunity. Rhabdovirus infectivity may persist in the environment, especially at alkaline pH, but is thermolabile and sensitive to UV irradiation. In clinical practice, rabies virus is easily inactivated by detergent-based disinfectants.

Viral entry into host cells occurs via fusion of the viral envelope with the cell membrane; all replication steps occur in the cytoplasm. Rabies virions are formed by budding of nucleocapsids through intracytoplasmic membranes of infected neurons, and in salivary gland epithelial cells mostly through plasma membranes. Replication is slow and usually non-cytopathic, because it does not shut down host protein and nucleic acid synthesis. Rabies virus produces prominent cytoplasmic inclusion bodies (Negri bodies) in infected cells.

Laboratory-adapted ('fixed') rabies virus strains replicate well in cell culture.

European Advisory Board on Cat Diseases
The European Advisory Board on Cat Diseases (ABCD) is a body of experts in immunology, vaccinology and clinical feline medicine that issues guidelines on prevention and management of feline infectious diseases in Europe, for the benefit of the health and welfare of cats. The guidelines are based on current scientific knowledge of the diseases and available vaccines concerned.

An extended version of the feline rabies guidelines presented in this article is available at www.abcd-vets.org

Overview Rabies virus belongs to the genus *Lyssavirus*, together with European bat lyssaviruses 1 and 2. In clinical practice, rabies virus is easily inactivated by detergent-based disinfectants.

Infection Rabid animals are the only source of infection. Virus is shed in the saliva some days before the onset of clinical signs and transmitted through a bite or a scratch to the skin or mucous membranes. The average incubation period in cats is 2 months, but may vary from 2 weeks to several months, or even years.

Disease signs Any unexplained aggressive behaviour or sudden behavioural change in cats must be considered suspicious. Two disease manifestations have been identified in cats: the furious and the dumb form. Death occurs after a clinical course of 1–10 days.

Diagnosis A definitive rabies diagnosis is obtained by post-mortem laboratory investigation. However, serological tests are used for post-vaccinal control, especially in the context of international movements.

Disease management
Post-exposure vaccination of cats depends on the national public health regulations, and is forbidden in many countries.

Vaccination recommendations
A single rabies vaccination induces a long-lasting immunity. Kittens should be vaccinated at 12–16 weeks of age to avoid interference from maternally derived antibodies and revaccinated 1 year later. Although some vaccines protect against virulent rabies virus challenge for 3 years or more, national or local legislation may call for annual boosters.

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The number of human rabies deaths is estimated at 40,000–100,000 worldwide each year, and an estimated 10 million people receive post-exposure treatment.

Epidemiology

Rabies occurs worldwide, with geographical exceptions. Large regions of Europe are now free of terrestrial rabies as a result of wildlife vaccination programmes. The rabies situation and the regulations are continuously updated on the websites of the World Organisation for Animal Health (OIE) and the World Health Organization (WHO) (Fig 1).[1]

The number of human rabies deaths is estimated at 40,000–100,000 worldwide each year, and an estimated 10 million people receive post-exposure treatment.[2] Dog rabies is still important in many parts of the world and is the principal cause of human cases. Wildlife rabies has increased in importance as a threat to domestic animals and humans, and transmission by vampire bats is a significant issue in Latin America. The red fox and the raccoon/skunk are the main reservoir species for terrestrial rabies in Europe and the Americas, respectively.

Rabies-free countries

Strictly enforced quarantine for dogs and cats has kept rabies from entering Japan, the United Kingdom (UK), Australia, New Zealand and other islands. Rabies was never endemic in wildlife in the UK and was eradicated in 1902, and again in 1922 after it had become established in the dog population in 1918. Since then, there has been no rabies in the UK. Isolated reports of bats infected with EBL-2 have not altered the terrestrial rabies-free status of the UK. In contrast, rabies was not recognised in Australia until the recent discovery of Australian bat lyssavirus, which was subsequently found to be endemic in southeast Australia.

A dreaded disease

Rabies is one of the oldest and most dreaded diseases of humans and animals – it was recognised in Egypt before 2300 BC, and well described by Aristotle in ancient Greece. Rabies also has stimulated one of the great early discoveries in biomedical science: in 1885, before the nature of viruses was understood, Louis Pasteur developed, tested and applied a rabies vaccine, thereby heralding the modern era of infectious disease prevention.

Developing countries

In most countries of Asia, Latin America and Africa, dog rabies is endemic, causing considerable mortality in domestic animals and man. Many people are vaccinated, and there is a continuing need for comprehensive, professionally organised and publicly supported rabies control agencies. Though such agencies cannot be afforded by many developing countries, progress is being made. For example, a substantial decrease in the incidence of rabies has been reported recently from China, Thailand and Sri Lanka, after implementation of dog vaccination programmes and improved post-exposure prophylaxis of humans. Similarly, rabies cases decreased in Latin America after the Pan American Health Organization had implemented a vaccination programme to eliminate urban dog rabies from the southern hemisphere.

Industrialised countries

In most industrial countries, even in those with a modest disease burden, publicly supported rabies control agencies undertake:

- Oral vaccination of wildlife – in Europe, the red fox;
- Stray dog and cat removal and control of pet movement (quarantine is used rarely in epidemic circumstances);
- Immunisation of dogs and cats, to break the chain of virus transmission;
- Laboratory diagnosis, to confirm clinical observations and obtain accurate incidence data;
- Surveillance, to measure the effectiveness of all control measures;
- Public education programmes to assist cooperation.

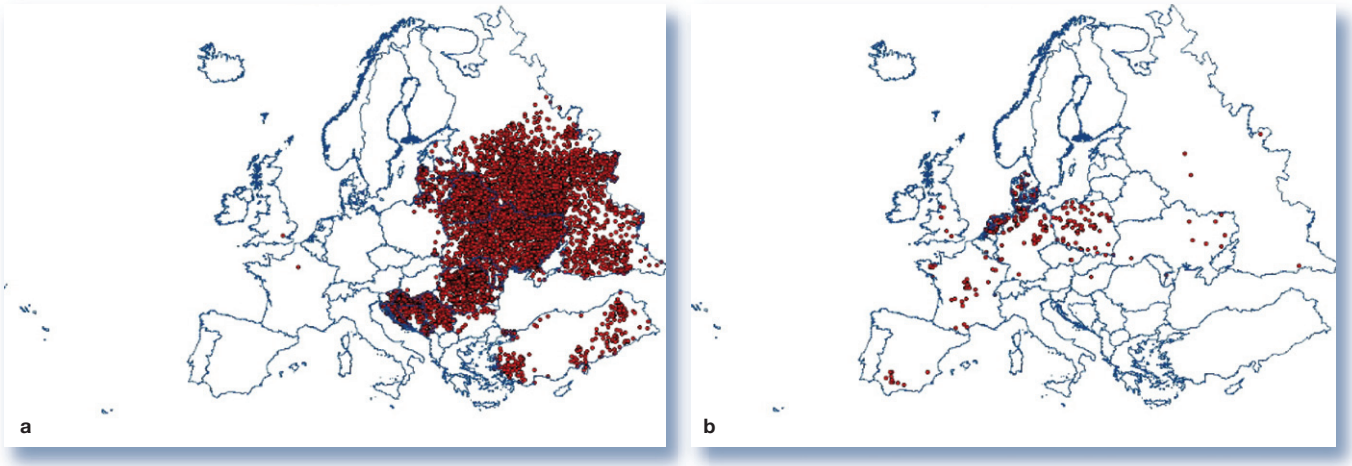


FIG 1 Incidence maps showing (a) terrestrial rabies cases in 2008; and (b) bat rabies cases between 1997 and 2008. *Source WHO*

Though fewer persons obtain post-exposure prophylaxis after cat bites, as compared with dog bites, the treatment is justified more often.

The cat is considered as being a high-risk species for rabies transmission to humans in some European countries: of more than 20,000 inhabitants in Switzerland that had to be vaccinated after exposure to rabies between the 1960s and 1990s, around 70% had been either bitten by, or in close contact with, cats.[3] Even if feline rabies is considered a 'by-product' of canine or wildlife rabies, feline behavioural characteristics and clinical aspects make it important for public health reasons. In fact, though fewer persons obtain post-exposure prophylaxis after cat bites, as compared with dog bites, the treatment is justified more often.[4]

Although unvaccinated cats may become infected with rabies following contact with rabid wildlife, such cases have become rare in Western Europe. Instead, most recent cases of terrestrial rabies have been traced to illegally imported, infected pets from rabies-endemic regions of Africa. Veterinary practitioners should therefore remain alert for signs of rabies in cats, even in rabies-free areas.

Pathogenesis

Rabid animals are the only source of infection. Virus is shed in the saliva some days before the onset of clinical signs and transmitted through a bite or a scratch to the skin or mucous membranes (eyes, nose, mouth). Rabid animals are not viraemic, and their blood is not infectious. The average incubation period in cats is 2 months, but may vary from 2 weeks to several months, or even years, depending on the transmitted virus dose, the severity of the wound and its localisation.[5,6] This must be taken into account when evaluating the wound history, especially when free-roaming cats exhibit sudden behavioural changes and/or signs of motor neuron dysfunction that may herald the clinical phase.

Why is the incubation period so variable?

The variability in the incubation period is explained by the pathogenic behaviour of the virus, which moves along peripheral nerves, with the normal axoplasmic flow, from the inoculation site to the central nervous system (CNS). The greater the distance from the CNS, the longer the incubation period; and the greater the density of innervation of the inoculated tissue, the shorter the incubation period.[7] Very long incubation periods have been observed in some experimental cases.[8]

The virus replicates in striated muscle and connective tissue at the site of inoculation, and from there enters the peripheral nerves through the neuromuscular junction.[9] Alternatively, it can infect peripheral nerves directly, spreading to the CNS via the axonal route. It then travels via the retrograde axonal route to reach the salivary glands, at which time the animal becomes infectious, usually about 3 days before clinical signs appear. Virus becomes widely disseminated throughout the organs. In most cases, death occurs within 5 days – an infected cat will therefore be shedding the virus in saliva for about 8 days in total. Most of the clinical signs are related to central and peripheral nervous system dysfunction, and abnormalities in neurotransmission, rather than to neuronal death.[5]

Immunity

Passive immunity acquired via colostrum

Kittens from vaccinated queens obtain maternally derived antibodies (MDA) via the colostrum, their titres depending on both the antibody titre of the queen and the amount of colostrum ingested during the first day of life. In most kittens, MDA will not persist for longer than 12 weeks.

Maternally derived antibodies may neutralise vaccine antigens, thereby inhibiting adaptive immunoglobulin production and interfering with the immunisation process during the first weeks of life. It is therefore recommended that vaccination of kittens should not start before 12 weeks of age.

Active immune response

Rabies virus antigens are highly immunogenic and can elicit the full spectrum of protective immune responses. However, the virus is not very cytopathic – cell lysis hardly occurs during replication and maturation, and little antigen is therefore presented to the immune system. Neither humoral nor cell-mediated responses can be detected during the early stages of viral movement from the site of the bite to the CNS.[10] Hence, infection of naive animals with rabies virus invariably results in death. Fortunately, this can be averted by prompt post-exposure immunisation, because anti-rabies viral immunity before extensive infection of neurons is protective.

Most recent cases of terrestrial rabies in Western Europe have been traced to illegally imported, infected pets from rabies-endemic regions of Africa. Veterinary practitioners should therefore remain alert for signs of rabies in cats, even in rabies-free areas.

Virus neutralising antibody is crucial in this immunity. Rabies is an example of a 'Th-2 healing disease' in which activation of B lymphocytes, with the help of CD4 T cells, mediates protection.[11] When activated, primarily by the nucleocapsid (N) protein, CD4 T cells produce cytokines that stimulate B cells to produce antibodies. In contrast, rabies-specific CD8 T cells cause neuronal damage when a Th-1 response predominates.[12,13] However, vaccinated animals without detectable virus neutralising antibody did survive a challenge infection, which hints at still other protective mechanisms.[14,15]

After intramuscular infection, the virus replicates locally in the myocytes or nervous tissue. In vaccinated cats, the invading virus is neutralised early during the incubation period, whereas unvaccinated cats may produce an antiviral immune response, but too late to prevent disease. Laboratory experiments have shown that protection early after infection is provided by the native immune system, with interferon playing a critical role.[16] It is not clear how effective these mechanisms are in naturally exposed naive cats. Morbidity-determining factors include the amount of virus transmitted, the strain, and the age and immunocompetence of the cat. A young, unvaccinated animal that has been bitten severely in the head, with a large saliva deposit in the wound, has a higher risk of developing rabies (with a shorter incubation period) than an adult cat bitten in a limb, especially after extensive bleeding.[17]

FIG 2 Any aggressive behaviour expressed by a cat should lead to a suspicion of rabies. *Courtesy of (a) Andy Sparkes; (b) AFSSA/ERZ*

In natural infections, neutralising antibody usually appears after the virus has entered the CNS. Hence, once symptoms are evident, recovery is exceedingly rare.[18] However, antibodies to lyssaviruses have been detected occasionally in domestic and wild cats with no history of vaccination, consistent with a non-fatal disease or subclinical infection.[19]

Clinical signs

Any unexplained aggressive behaviour or sudden behavioural change in cats should be considered suspicious (Fig 2). Rabies should be suspected not only when there has been a recent history of a bite or exposure to a rabid animal, but also where a cat has had contact with wildlife, particularly bats. Indeed, a cat in France died of rabies as the result of an infection with bat lyssavirus. However,

Clinical signs

Typical clinical picture for rabid cats infected with rabies virus

History and clinical signs reported by the owner
- Dramatic changes from normal behaviour
- Very aggressive: biting people and/or animals with no apparent reason

General appearance and clinical signs at presentation
- 90% of rabid cats show clinical signs of the furious form
- Thin body condition (the cat does not eat)
- Ruffled and dirty coat (the cat does not clean itself)
- Mucous membranes, tongue, nose and footpads are reddish pink (high fever)
- The chin and front legs are wet from salivation
- Perpetual movement and excitement (restlessness)
- Imbalanced gait due to paresis of the hind legs
- Pupil dilation unresponsive to light
- Abnormal water uptake (water runs back out of mouth)

Courtesy of Veera Tepsumethanon

Rabies should be suspected not only when there has been a recent history of a bite or exposure to a rabid animal, but also where a cat has had contact with wildlife, particularly bats.

FIG 3 Cats in the paralytic phase of rabies. Note the anisocoria. *Courtesy of (a) Artur Borkowski; (b) AFSSA/ERZ; (c) Merial*

although rabid bats have been reported in the UK, and the Mammal Society has estimated that British cats kill about 230,000 bats a year, no cases of cat rabies are on record.[20,21] These findings indicate a low risk of cats becoming infected with lyssaviruses from bats.

Two disease manifestations have been identified in cats: the furious and the dumb form. The furious form has three clinical phases (prodromal, mad or psychotic, and paralytic) but these are not always distinct in cats. In the dumb form, the 'mad' phase is lacking. During the short (12–48 h) prodromal phases of both forms, non-specific clinical signs (fever, anorexia, vomiting, diarrhoea) occur, sometimes accompanied by neurological signs. Behavioural changes may be the first to be noticed, such as unusually friendly manners, a shy or irritated conduct, or increased vocalisation. These indicate forebrain involvement and are later associated with other neurological signs. Cranial nerve involvement may produce depressed or absent reflexes (palpebral, corneal, pupillary), strabism, dropped jaw, inability to move whiskers forward, dysphagia, laryngeal paralysis, voice change and tongue paralysis (Fig 3). Forebrain involvement is responsible for seizures, muscular twitching or tremors, aimless pacing, exaggerated emotional responses (irritability, rage, fearfulness, photophobia, attacking inanimate objects).

The tendency to bite indiscriminately may be due to loss of inhibitory control by cortical neurons over the subcortical bite reflex; these cats turn and snap at anything that touches them around the mouth, without warning or showing any emotion. Pruritus at the bite site has been observed.[22]

If a limb was bitten, then neurological signs start from the spinal cord, with an ascending lower motor neuron paralysis occurring before the brain signs. The encephalitis rapidly spreads throughout the CNS producing ataxia, disorientation, paralysis, seizures and status epilepticus, ultimately followed by coma and death from respiratory arrest.

The furious form is more often seen in cats, which show behavioural abnormalities, as described above.[23] The paralytic phase (paraparesis, incoordination, generalised paralysis, coma and death) usually begins a few days after the first clinical signs.

Isolated case reports of rabies survival have been published for cats, dogs and humans, but death usually occurs after a clinical course of 1–10 days.[18,24] Cats often die within 3–4 days[25] (25% of fatalities occur within 4 days), while progression in dogs is more rapid (2 days).[26] Atypical forms with a chronic course have been described in cats after experimental infection.[8]

Vaccine-induced rabies in cats was observed in the past when modified-live virus vaccines were used. Neurological signs occurred several weeks after vaccination and were characterised mostly by progressive upper motor neuron limb paralysis and cranial nerve deficits.

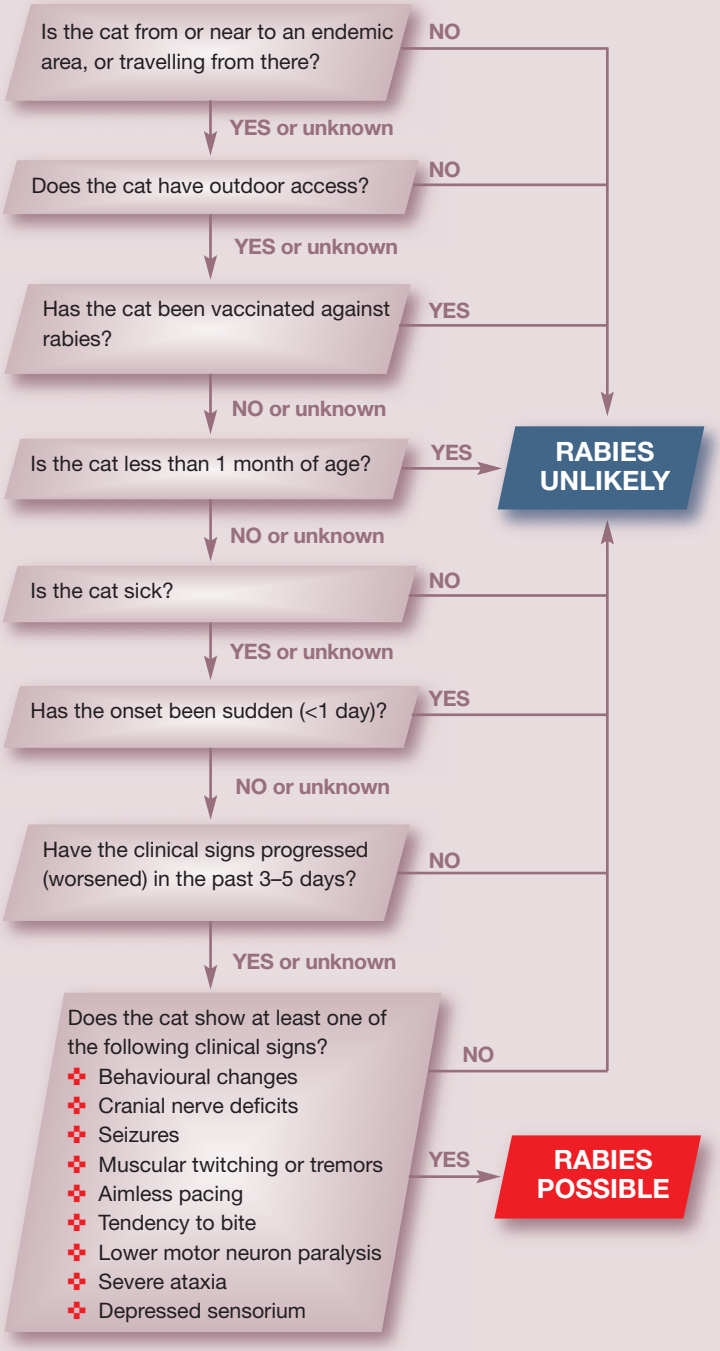
Minimising public health risks

The substantial public health risk (particularly for veterinarians) requires that the differential diagnoses for CNS diseases characterised by sudden-onset and rapidly evolving clinical signs should always include rabies for free-roaming, unvaccinated cats living or travelling in endemic areas. Indeed, rabies should be included in the differential diagnosis for any cat with suspected encephalitis. Safety must always be the overriding priority. Manipulation and restraint of the cat may provoke biting at a time when the salivary glands are already infected. The ABCD stipulates that the differential diagnosis should be based on the cat's history (see box on page 590), and observation of the animal inside the carrier, with a view to reducing the risks of exposure to veterinary personnel.

Diagnosis

A definitive rabies diagnosis is obtained by post-mortem laboratory investigation. However, serological tests are used for post-vaccinal control, especially in the context of international movements.

Assessing the likelihood of rabies



Adapted from Tepsumethanon et al[46]

OIE recommendations

The following are recommendations from experts at the OIE First International Conference 'Rabies in Europe' (Kiev, 15–18 June 2005):

- Routine laboratory diagnosis should be undertaken using only the techniques specified by the OIE (Terrestrial Manual) and the WHO (Laboratory Techniques in Rabies);
- The fluorescent antibody test is the primary method recommended;
- Confirmation should be based on the rabbit tissue culture inoculation test. The mouse inoculation test can be used only if rabbit tissue culture is not available;
- PCR is presently not recommended for routine diagnosis but may be useful for epidemiological studies or for confirmatory diagnosis only in reference laboratories.

The list of reference experts and laboratories can be found on the OIE website (www.oie.int).

Virus and antigen detection

To confirm rabies in people and animals, only direct virus or antigen detection methods are used. Brain tissue (especially thalamus, pons and medulla) is preferred for post-mortem diagnosis, but other organs (eg, salivary glands) are also used. Samples should be shipped according to the national and international regulations, and care should be taken to avoid contamination. The specimens should be shipped refrigerated for virus isolation or at room temperature in 50% glycerol/phosphate-buffered saline.

- **Fluorescent antibody test** The fluorescent antibody test (FAT) is recommended by the WHO and OIE for fresh or glycerol samples.[27] On fresh samples, FAT provides a reliable diagnosis in 95–99% of all lyssavirus cases; on formalin-fixed tissue the test is less sensitive. It can also be used to detect virus in cell culture and in brain tissue of mice that had been inoculated with homogenates of suspected material.
- **Immunochemical tests** Other suitable methods include immunochemical tests using the avidin–biotin peroxidase system, ELISA, and direct blot enzyme immunoassay. The rapid rabies enzyme immunodiagnosis is an alternative to FAT but detects only the 'classical' rabies virus; agreement with the FAT is between 96 and 99%.[28]
- **Inoculation to laboratory animals and cell cultures** Inoculation techniques and cell cultures are used to confirm inconclusive results obtained with FAT on organs or negative results when human exposure has been reported. Newborn or 3–4-week-old mice are inoculated intracerebrally, and FAT is used to detect the virus 5–11 days later. Animal inoculation tests should be replaced by cell culture tests, which are as sensitive, less time consuming and ethically acceptable. Rabies virus replicates in mouse neuroblastoma cell lines, and the presence of antigen is revealed by FAT, with results available within 2–4 days.
- **Histology and immunohistochemistry** Histological and immunohistochemical methods to detect Negri bodies are of low sensitivity, especially in autolysed tissues, and are not recommended for routine diagnosis.

✣ **Other direct methods** Monoclonal antibodies, nucleic acid probes or PCR and sequencing can be used by reference laboratories to identify rabies virus, especially some variants. These techniques can distinguish vaccine and field strains and may identify the geographic origin of the strain.

Antibody detection

✣ **Seroneutralisation tests** Techniques such as fluorescent antibody virus neutralisation (FAVN) or rapid fluorescent focus inhibition (RFFIT) are widely used. The former test is based on the neutralisation of a given concentration of rabies virus (CVS strain) in vitro before inoculating BHK-21 C13 cells. The antibody concentration is determined by titration; however, it is not expressed as a titre value (reciprocal of serum dilution) but in International Units per millilitre (IU/ml), by comparison with an OIE standard serum of dog origin (OIE Reference Laboratory for Rabies, Nancy, France). A value of 0.5 IU/ml has been defined as the minimum to correlate with immune protection. The two techniques, RFFIT and FAVN, give equivalent results.

✣ **ELISA** ELISA kits for the detection of antibodies in sera from vaccinated cats and dogs are commercially available. Test results can be obtained within 4 h. The sensitivity and specificity of these tests need to be assessed before they can be officially accepted.[29–31]

Disease management

Post-exposure treatment

Post-exposure vaccination of cats depends on the national public health regulations. It is forbidden in many countries and usually not authorised in cases of clinical suspicion. Supportive or specific treatment is ineffective in rabid cats, and treatment is not considered, likewise for public health reasons.[7]

Preventive vaccination

Because of the public health risk, rabies vaccines are core vaccines in countries where rabies is endemic (see box below), and they must be administered in accordance with local or state regulations. In countries without rabies, vaccination is optional; it is recommended if a cat should move into a rabies-endemic area.

Vaccination

General considerations

Feline rabies is controlled mostly by inactivated vaccines.[30] Several products containing the rabies virus are on the market, which induce protection after a single injection.[33] In cats and dogs, rabies neutralising antibodies generally peak between 4–6 weeks after the first immunisation. The available vaccines are very efficient: cats and dogs with neutralisation values higher than 0.5 IU/ml – regardless of the time elapsed since vaccination – have a high probability of surviving a rabies virus infection. Cats respond better than dogs; >97% of cats have been shown to develop antibody concentrations ≥0.5 IU/ml after the first vaccination, many even >5 IU/ml.[33] Only a tiny proportion of cats that succumbed to rabies had a vaccination history of one injection or more.[7] Since 1993, when the new EU regulations on pet movement were put in place, no single case of vaccine failure has been documented.[33] Rabies vaccines are generally considered to be safe, even in neonatal kittens.

Inactivated vaccines may carry a risk of incomplete virus inactivation, but this is very small.[34] They have also been associated with the development of injection site sarcomas in cats.[35]

These considerations led to continued efforts to develop safer rabies vaccines. New products include recombinant subunit proteins, recombinant viral vectors and DNA-based vaccines.[36–40] Recombinant live vector vaccines have some advantages over traditional vaccines: they are innocuous, induce adequate humoral immune responses and do not require rabies virus to be handled.[37] They also induce less inflammation at the site of injection.[41]

Fortunately, current vaccines cross-protect against other lyssaviruses. All cat and dog sera containing >5 IU/ml neutralise EBL-1 and EBL-2, regardless of vaccine/virus strain; of sera with values between 0.5–5 IU/ml, 87% neutralise EBL-1 and 53% EBL-2 (AR Fooks, personal communication). However, depending on the genetic distance between novel isolates from bats in Eurasia and 'classical' rabies virus, protection may not be sufficient.[42]

Core/optional vaccine

Because of the public health risk, rabies vaccines are core vaccines in countries where rabies is endemic, and they must be administered in accordance with local or state regulations. In countries without rabies, vaccination is optional; it is recommended if the cat should move into a rabies-endemic area.

Primary course

In contrast to all other inactivated vaccines, a single rabies vaccination induces long-lasting immunity. Kittens should be vaccinated at 12–16 weeks of age to avoid interference from MDA, and revaccinated 1 year later (depending on the data sheet recommendations for the respective brand of vaccine). National or regional legislation regarding vaccination type and intervals should be adhered to.

Cats respond better than dogs; >97% of cats developed antibody concentrations ≥0.5 IU/ml after the first vaccination, many even >5 IU/ml.

Booster vaccination

Although some vaccines protect against virulent rabies virus challenge for 3 years and upwards, national or local legislation may call for annual boosters.[43]

KEY POINTS

- Rabies occurs worldwide, with geographical exceptions. Large regions of Europe are now free of terrestrial rabies as a result of wildlife vaccination programmes.
- The cat is considered as being a high-risk species for rabies transmission to humans in some European countries.
- Virus is shed in the saliva some days before the onset of clinical signs.
- The average incubation period in cats is 2 months, but may vary from 2 weeks to several months, or even years.
- Due to the presence of colostral antibodies, it is recommended that vaccination of kittens is not started earlier than 12 weeks of age.
- There is a low risk of cats becoming infected with rabies virus or other lyssaviruses from bats.
- Two disease manifestations have been identified in cats: the furious and the dumb form. Nearly all rabid cats (90%) show the furious form.
- Death usually occurs after a clinical course of 1–10 days. Cats often die within 3–4 days.
- Feline rabies is controlled mostly by adjuvanted inactivated vaccines, which induce protection after a single injection.
- Cats respond better than dogs, with more than 97% developing antibody concentrations ≥0.5 IU/ml after the first vaccination.
- Kittens should be vaccinated at 12–16 weeks of age and revaccinated 1 year later.
- Some vaccines protect against virulent rabies virus challenge for 3 years and upwards, but national or local legislation may call for annual boosters.

Disease control in specific situations

Shelters

In rabies-endemic areas, stray cats should always be approached with caution. Handling and nursing of rescued animals should be considered hazardous, even if they appear healthy.

Breeding catteries

Breeding catteries are not at risk, because pedigree cats are usually kept strictly indoors; their vaccination may be required under local or state regulation.

Immunocompromised cats

- **Feline leukaemia virus (FeLV) or feline immunodeficiency virus (FIV) positive cats** In rabies-endemic areas, FIV-seropositive cats should be kept indoors. Though this is an effective preventive measure, national or regional legislation must be adhered to. For outdoor cats with a risk of exposure to rabies virus, vaccination is strongly advised. Feline leukaemia virus-positive cats may not be able to mount adequate immune responses to some rabies vaccines.[44] If FeLV-infected cats are allowed to roam in rabies-endemic areas (this is not recommended), more frequent vaccinations (eg, every 6 months) are justified.
- **Cats with concurrent disease** Cats with any acute illness should not be vaccinated. Those with chronic conditions, such as renal disease, diabetes mellitus or hyperthyroidism, should be vaccinated regularly if they are at risk of exposure.
- **Cats receiving corticosteroids or other immunosuppressive drugs** In cats receiving corticosteroids or other immunosuppressive drugs, the need for vaccination should be considered carefully. Depending on dosage and duration of treatment, corticosteroids may cause functional suppression of (particularly cell-mediated) immune responses, but studies for rabies vaccines are lacking. In dogs, corticosteroids do not appear to result in ineffective immunisations if given for short periods at moderate doses.[45] In general, concurrent use of corticosteroids and vaccines should be avoided.

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