The application of vaccines in pet diseases

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Abstract. With the changing times, most people have pet cats or dogs. In order to ensure the safety of pets, most people choose to have their pets vaccinated to prevent infectious diseases, as vaccination is widely recognized as one of the most effective and safe preventive measures. The initial vaccine was made due to smallpox virus, and at that time, technology was not advanced. The most primitive method was to inactivate the toxicity of the pathogen while maintaining its immunogenicity. The advantage of this vaccine lies in its stability and safety. Currently, most vaccines are inactivated vaccines. Later on, attenuated vaccines emerged, which were treated with formaldehyde to reduce toxicity but still maintain immunogenicity. The advantage of attenuated vaccines is that they have a longer immunization time, but there are also some unstable factors because the pathogen still retains some toxicity. There is also a type of genetic engineering vaccine, which can be divided into many types, such as genetic engineering subunit vaccines, recombinant virus vector vaccines, nucleic acid vaccines, etc. There are three main types of pet vaccines, each of which plays an important role but also has certain limitations. This article conducts a thorough review on pet diseases and the application of these three categories of vaccine, illustrating its mechanism, efficacy and limitation.

Keywords: pet disease; pet vaccines; inactivated vaccines; attenuated vaccines; genetic vaccines.

1. Introduction

Pet vaccines are an essential part of pet breeding, and some common pet viruses can be very dangerous for pets. For example, rabies virus, which causes rabies, is a zoonotic infectious disease with many susceptible animals. The common mode of transmission is scratching or biting, and once infected with rabies virus, the mortality rate of rabies outbreak can reach 100% [1]. Pet cats and dogs have similar symptoms of rabies, which can be divided into three stages after onset: prodromal phase, excited phase, and paralyzed phase. Feline panleukopenia virus, infected with this virus, can develop feline panleukopenia, also known as feline distemper fever. The clinical manifestations are often characterized by sudden high fever, stubborn vomiting, diarrhea, dehydration, and mainly reduced white blood cells. Under normal circumstances, the mortality rate of cats under 1 year old is 50% to 60%, and the mortality rate of cats under 5 months old can reach as high as 80% to 90%. This virus not only infects pet cats, but also other feline animals (such as lions, leopards, etc.) as well as non feline animals (minks, raccoons, etc.) [2].

The common diseases mentioned above can be treated by taking medication to enhance resistance. In addition, vaccination can be used to prevent related diseases. Vaccines contain weakened or dead components of pathogens, or surface proteins of pathogens, which stimulate the body of the vaccinated individual to produce an immune response. The body recognizes these components as foreign substances and produces corresponding immune cells and antibodies. In this way, when the vaccinated individual comes into actual contact with the pathogen in the future, the body can quickly and effectively produce an immune response, thereby preventing the occurrence of the disease or alleviating the condition.

2. Discovery of the earliest vaccine

The production process of pet vaccines can be mainly divided into three categories, among which inactivated vaccines are the earliest vaccines, and the discovery of inactivated vaccines can be traced back to smallpox virus. Smallpox virus, belonging to the family Poxviruses and genus Orthopoxvirus,

is the pathogen that causes human infection with smallpox and poses a significant threat to human life and health. Smallpox is one of the oldest infectious diseases in the world, with a mortality rate of up to 30%. As early as 998-1022 AD, during the reign of Emperor Zhenzong of Song, smallpox was prevalent. An official was afraid that his son would also be infected with smallpox, so he asked a person from Mount Emei to use a method to prevent smallpox infection. He took the scabs of smallpox patients, ground them into fine powder, and blew them into the nostrils of healthy children with bamboo tubes. After that, the children would suffer from a mild or asymptomatic smallpox. During the onset of the disease, resistance to smallpox is acquired. Later, this method spread to Europe in the early 18th century. Inspired by Chinese vaccination technology, British doctor Edward Jenner found that milking women would not get smallpox because they had been infected with cow pox. After nearly a decade of research, Dr. Jenner believes that cowpox virus is similar to smallpox virus that infects humans, but infection with cowpox virus does not result in death. So on May 14, 1796, Jenner conducted a public experiment in which he extracted cowpox pus from the blisters on a milkmaid's hand and made a cut on the arm of a child at his home, infecting him with the cowpox pus through the wound. The little boy developed a mild fever that lasted for several days and recovered after two weeks. When Jenner infected him with smallpox pustules again, he did not contract smallpox. People have discovered that immunity to this virus can effectively prevent infection, and thus vaccines have been developed.

Since the discovery of vaccine, great improvement has been achieved. Except for the earliest discovered inactivated vaccine, some new types of vaccines are developed, as shown in figure 1, including live attenuated vaccine, virus-like particles (VLPs), recombinant subunit, synthetic peptides, DNA or RNA and recombinant viral vectors, the last five could be grouped into genetic vaccine. Based on this classification, their application and production process are dissected below.

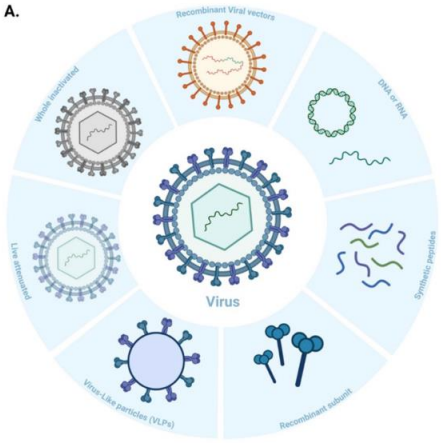

Fig. 1 Classification of vaccine [3].

3. Production and Application of vaccine

3.1. Inactivated vaccine

The earliest vaccines were made by inactivating the virus with formaldehyde or other substances to make it lose its infectivity, known as "inactivated vaccines". With the development of technology, glutaraldehyde, a chemical reagent, is now widely used to prepare inactivated vaccines. Inactivated vaccines have low pathogenicity, but they retain immunogenicity. After vaccination on sick pets, it can be used as a mechanism for qualitative analysis, but there is a certain immunogenicity of pathogens that can cause this immune response in animals. And help the virus establish this memory based immune response, which can quickly stimulate the disease cells to produce corresponding antibodies to respond to the next infection with the same virus. There are many types of inactivated vaccines currently used on animals. For example, the cat triple vaccine is used to prevent three

diseases: feline rhinotracheitis, feline panleukopenia, and feline panleukopenia [1]. Feline rhinotracheitis is an acute contact infectious disease caused by feline herpesvirus type 1, also known as feline herpesvirus infection. The mortality rate of cats infected with this virus is around 50%. After infection, mild symptoms include sneezing, runny nose, nasal congestion, tears in the eyes, occasional coughing, and fear of cold. Severe cases can lead to acute upper respiratory tract infections, characterized by sneezing, runny nose, conjunctivitis, excessive eye discharge, salivation, drowsiness, loss of appetite, fever, and cough, which typically last for several days to weeks. It can also cause corneal inflammation, leading to eye pain and blurred vision. Even causing skin inflammation and ulcers, commonly around the nose and mouth [4]. Vaccination with the triple vaccine for cats can effectively prevent infection with the above three viruses, providing a guarantee for the safety of pets.

3.2. Attenuated vaccine

Attenuated vaccines, also known as live attenuated vaccines, refer to a type of vaccine that retains antigenicity by reducing the toxicity of pathogens after formaldehyde treatment, while still maintaining their immunogenicity and reproductive ability. This is achieved by altering the structure of toxic subunits, while maintaining the activity of binding subunits. Vaccinating it into the body will not cause disease, but the pathogen can trigger an immune response in the body, stimulating the production of specific memory B cells and memory T cells. Plays a role in obtaining long-term or lifelong protection. Compared with inactivated vaccines, this type of vaccine has stronger immunity and longer duration of action, but it has potential pathogenic risks.

For example, the dog vaccine pentavalent contains five major canine disease viruses, namely canine distemper virus, canine infectious hepatitis virus, parainfluenza virus, canine coronavirus, and canine parvovirus. These viruses pose a great danger to the life safety of dogs. For example, canine distemper virus (CDV), which belongs to the Paramyxoviridae family and the measles virus genus in classification, is an ancient virus that naturally hosts canids and weasels, with dogs being the most commonly infected. This virus is mainly transmitted through air and droplets. Sick dogs are an important source of infection, which can cause long-term detoxification through urine, pollute the surrounding environment, and lead to virus transmission. The symptoms of canine distemper virus infection are diverse and related to virus virulence, environmental conditions, host age, and immune status. They can be mainly divided into four types: acute type, subacute type, chronic type, and latent infection type. CDV infection types are complex and diverse, making clinical diagnosis difficult and easily confused with upper respiratory tract infections, canine infectious hepatitis, canine coronavirus infections, etc. The canine distemper caused by it is a highly contagious disease with strong infectivity and a mortality rate of over 80% [5]. After receiving the canine pentavalent vaccine, dogs will produce immune antibodies against five viruses, enhancing their resistance and reducing disease and mortality rates.

3.3. Genetic engineering vaccine

Genetic engineering vaccines are vaccines made by cloning and expressing protective antigen genes using recombinant DNA technology, and utilizing the expressed antigen products or recombinant bodies themselves. Genetic engineering vaccines can be divided into genetic engineering subunit vaccines, recombinant viral vector vaccines, nucleic acid vaccines, and live vaccines with gene deletions [6]. For example, rabies vaccine is mainly used to prevent rabies caused by rabies virus infection. Rabies is an acute zoonotic infectious disease caused by the rabies virus, and almost all warm blooded animals are susceptible, with dogs and cats being the main storage hosts. Because the rabies virus cannot invade skin without exposed wounds, most cases of rabies are caused by bites or scratches from animals such as rabid dogs. After entering a pet's body, the rabies virus has a latent period. The rabies vaccine can stimulate the body to produce antibodies, effectively preventing the virus from spreading in the nervous system. If the rabies vaccine is not administered in a timely manner, the mortality rate of rabies caused by the rabies virus can reach 100% once it occurs. After onset, it can be roughly divided into prodromal phase, excitatory phase, and paralyzed phase. Dogs

usually exhibit berserk behavior, with affected dogs emitting frequent roars, actively attacking other dogs, animals, and humans. In addition, they may also experience fear of water and excessive drooling. The main symptoms of early rabies infection in dogs are mental depression and abnormal behavior, such as not listening to calls and exhibiting paranoia. As the condition worsens day by day, sick dogs will exhibit manic and restless behavior, showing aggression towards humans and other animals. Overall, the affected dog will gradually lose weight, have a drooping tail, and be sandwiched between its hind legs. And its voice will gradually become hoarse and drooling will increase. In the later stage, as the body loses control, it will show difficulty breathing and eventually die of exhaustion. After being infected with rabies, cats exhibit symptoms similar to dogs, with two main types: manic and paralyzed, generally divided into three stages. During the prodromal period, cats may suddenly exhibit abnormal behavior, such as making unconscious actions, ignoring their owners, and biting. During the berserk period, cats may experience fear and manic emotions, such as fear of water, light, and sound. They have strong aggressiveness, attacking humans and animals and even biting themselves. Due to facial muscle paralysis, their calls gradually become hoarse and swallowing becomes difficult. During the paralysis period, the cat's mental state becomes suppressed, manic symptoms disappear, limbs become stiff, often lie on the ground, breathing is suppressed, and ultimately dies due to multiple organ failure and respiratory paralysis. The rabies vaccine significantly increases the safety of pet ownership, while also ensuring that pets and owners have a high probability of not being infected with the rabies virus.

4. Conclusion

At present, vaccines used for pets are divided into the three categories mentioned earlier, including the inactivated vaccines, the attenuated vaccines and genetic engineering vaccines. In principle, they are all made into automatic immune preparations for preventing infectious diseases by using pathogenic microorganisms (such as bacteria, rickettsia, viruses, etc.) and their metabolites through these three methods, retaining the characteristic of pathogenic bacteria stimulating pet immune systems. When a pet's immune system comes into contact with this harmless pathogen, it produces certain protective substances, such as immune hormones. When pets come into contact with this pathogen again, their immune system will follow their original memory and produce more protective substances to prevent the pathogen's damage. At present, pet vaccines have good preventive effects, but with the advancement of technology, the latest mRNA vaccines have significant advantages over traditional vaccines, such as high production efficiency and low cost. Moreover, mRNA vaccines have high immunogenicity and can induce stronger immune responses. However, there are also some limitations, such as the instability of mRNA, which poses challenges in terms of stability [7]. However, with the development of technology, it is believed that these problems will be solved, and mRNA vaccines will become increasingly important in the field of vaccines, reflecting more value.

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