Journal of Advances in Medical and Pharmaceutical Sciences

20(2): 1-10, 2019; Article no.JAMPS.37477
ISSN: 2394-1111

The Current Status of Veterinary Vaccinology: A Review

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JAMPS/2019/v20i230108
Editor(s):
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Complete Peer Review History: http://www.sdiarticle3.com/review-history/37477

Review Article

Received 07 September 2017
Accepted 21 November 2017
Published 23 April 2019

ABSTRACT

This paper was done starting from February 2017 to July 2017 in Jimma University College of Agriculture and School of Veterinary Medicine. The suffering of different animal species from multiple infectious agents in and around the university leads us to be conscious and enabled us to write this scientific paper which can be acts as the source of information for Veterinary vaccinology. Louis Pasteur in the 19th century demonstrated the ability to protect chickens against fowl cholera (*Pasteurella multocida*) and thus demonstrated the benefit of vaccination in animals and paved the way for the development of the array of veterinary vaccines which are in use today. Since Pasteur's work, vaccination against infectious disease have been used successfully to protect animals from many serious diseases some of which were also significant risks to humans. Veterinary vaccine has a parallel way of development in research and development of vaccines in the human field vaccinology today also. Vaccine is a biological preparation that improves immunity to a particular disease. Vaccine contains an agent that resembles a disease-causing microorganism and is often made from weakened or killed forms of the microbe or its toxins. The general information concerning veterinary vaccination such as common vaccination, common methods of veterinary vaccination,

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principles of vaccination; standardization of veterinary vaccines, generation of vaccine, vaccine formulation, new approaches to veterinary vaccines and few other information were roughly reviewed from scientific journals, experiment results, proceedings, reference books and manuals. The objectives of this paper are to highlight the general current information of Veterinary Vaccinology and to give specific recommendations based on the facts obtained.

Keywords: Vaccinology; veterinary; current information; recommendations.

1. INTRODUCTION

Louis Pasteur in the 19th century demonstrated the ability to protect chickens against fowl cholera (*Pasteurella multocida*) and thus demonstrated the benefit of vaccination in animals and paved the way for the development of the array of veterinary vaccines we have today. Since Pasteur's work, vaccination against infectious diseases have been used successfully to protect animals from many serious diseases some of which were also significant risks to humans. Veterinary vaccine development has paralleled the research and development of vaccines in the human field. However, in veterinary medicine there is a much wider range of products reflecting the diversity of animal species and the plethora of diseases that may commonly affect companion and food producing animals. Due to the incidence of many common, life-threatening and devastating diseases are now low and the development of safe and effective veterinary vaccines can be said to have been a major success for improvement in animal health and welfare [1].

Vaccine is a biological preparation that improves immunity to a particular disease. Vaccine contains an agent that resembles a disease-causing microorganism, and is often made from weakened or killed forms of the microbe or its toxins. The agent stimulates the body`s immune system to recognize the agent as foreign, destroy it, and remember it, so that the immune system can more easily recognize and destroy any of these micro-organisms which is later encounters. The term *vaccine* is developed by Edward Jenner`s in 1796 by the use of the cow pox which, when administered to humans, provided them protection against smallpox [2].

Protecting animals from infection is a major obligation of every veterinarian's work in order to preserve animal welfare while assuring human health. Highly infectious animal diseases can reduce the performances of food producing animals and may have a great economical impact on many industries. A reliable supply of pure, safe, potent, and effective vaccines are essential for maintenance of animal health and the successful operation of animals' health programmes. Immunization of animals with high quality vaccines is the primary means of control for many animal diseases. The requirements and procedures described here are intended to be general in nature and to be consistent with published standards that are generally available for guidance in the production of veterinary vaccines [2].

However, success in disease control is often followed by new challenges. A healthy debate of the pros and cons of vaccination is valuable as it is entirely possible that a disease can become so rare that risks associated with vaccination can outweigh the risk of contracting the illness. Advising on the correct vaccination method is not an easy task as a routine programme of vaccination may require adaption to the local epidemiology of the various diseases to provide the best health security. It is right therefore, that the decision is taken by the animal owner following discussion and advice from their veterinary surgeon. Independent assessment seeks to ensure three major factors are in place before any vaccine is made available for use:

- Vaccines are manufactured to a consistent and acceptable quality using high grade materials and are uncontaminated with potentially harmful infectious agents or other toxic substances;
- Vaccines are safe to be administered to young and older animals where relevant, and pose no risk to the owner, their families or other animals and persons coming in contact with vaccinated animals. Where necessary, specific warnings are added to the product literature to minimize any risk of an adverse reaction following administration of the product
- High quality scientific data are available to support the primary and any re-vaccination (booster) schedule and this has been assessed to ensure the vaccine can be expected to provide the required onset and

duration of immunity claimed by the manufacturer to protect animals against disease.

Non-core vaccines are vaccines for animals whose geographical location, local environment or lifestyle places them at risk of contracting other specific infections. There are approximately 316 veterinary vaccines or immunological products currently holding Marketing Authorizations in the UK for companion animals, horses and the major food producing animals. The majority of these are multivalent vaccines containing a number of antigens to protect against a range of important diseases. The maximum duration of immunity for some of the core vaccines has been justified as three years with a range for all vaccines extending between 1-3 years [1].

Vaccinology is the discipline in biomedical research that aims to study the various aspects of vaccine, vaccine production technology and vaccine quality control. Its roots date back until the 2nd half of the 19th century with landmarks such as the development of the rabies vaccine by Louis Pasteur (1885) and the introduction of the serum therapy (anti-toxins) for Diphtheria by Emile von Behring and Shibasaburo Kitasato (1891). Vaccinology is a key element in current health care programs and has been instrumental to the world-wide decrease in infant mortality [1]. However, in terms of laboratory animal use, there is a price to pay. Substantial numbers of animals are required for each aspect of vaccinology and, in comparison to other areas of biomedical research; a relatively high percentage of the animal models involves severe pain and suffering [1].

2. OBJECTIVES OF VACCINOLOGY

There are a number of factors that affect emerging infectious diseases including:

- Introduction of infection into new host populations
- Establishment and further dissemination within new host population
- Agricultural or economical development
- Human demographics and behavior
- Microbial adaptation

Unfortunately, the capacity to address emergence or re-emergence of infectious diseases is limited by

- Lack of efficacious vaccines or therapeutic treatment modalities,
- Limited support for and deterioration of surveillance of vector-borne and zoonotic diseases,
- Erosion in the number of scientists and public health investigators,
- Veterinarians who are educated in relevant fields that include medical entomology, vectorecology, epidemiology, tropical medicine, and microbiology of zoonotic pathogens,
- Limited tools to address emergence of drug resistant pathogens, arthropod vectors and biosafety facilities.

Therefore, the objectives of Veterinary vaccinology

1/ To improve the health and productivity of domestic livestock, poultry, fish, and other income producing animals and wildlife through vaccination
2/ To assist in preventing disease epidemics by providing laboratory resources and highly skilled scientific personnel
3/ To have Safe and efficient food production
4/ To Control of emerging and exotic diseases of animals and people
5/ To assist in protecting human health through the control of animal diseases transmissible to man,
6/ To Reduce the transmission of food borne disease,
7/ To reduce the need for antibiotics to treat animals,
8/ To improve the health of companion animals, which serve to enrich the lives of human kind,
9/ To train new scientists in animal health research in order to provide continuity and growth in vital area of veterinary medicine [3].

3. COMMON VACCINATION

Vaccines play an important role in the control of infectious diseases and in preventive health care programs for humans and animals. In particular, veterinary vaccines have been called the core products of animal health, and have contributed to the eradication or control of many of the most devastating diseases of livestock, poultry and pet animals, such as foot and mouth disease, rinderpest, classical swine fever, Newcastle disease, canine distemper and parvovirus's [4].

Moreover, veterinary vaccines are considered crucial tools in controlling infectious diseases such as brucellosis and rabies that can be transmitted from animals to human, and therefore, are of major concern for public health.

Vaccination was the term firstly adopted by Edward Jenner for the process of inoculating humans with weakened or killed “immunogens” obtained from cowpox to prevent them from getting smallpox. One hundred years later, Louis Pasteur who had built on his work on the basis of Jenner’s one, adopted the name of vaccine as a generic term for the protective inoculation of any “immunogens” designed to stimulate an immune response to an infectious disease [5].

4. PRINCIPLES OF VETERINARY VACCINATION

A reliable supply of pure, safe, potent, and effective vaccines is essential for maintenance of animal health and the successful operation of animal health programmes. Immunization of animals with high quality vaccines is the primary means of control for many animal diseases. In other cases, vaccines are used in conjunction with national disease control or eradication programmes. The requirements and procedures described here are intended to be general in nature and to be consistent with published standards that are generally available for guidance in the production of veterinary vaccines. The approach to ensuring the purity, safety, potency, and efficacy of veterinary vaccines may vary from country to country depending on local needs. However, proper standards and production controls are essential to ensure the availability of consistent, high quality products for use in animal health programmes. As the pathogenesis and epidemiology of each disease varies, the role and efficacy of vaccination as a means of control also varies from one disease to another. Some vaccines may be highly efficacious, inducing an immunity that not only prevents clinical signs of the disease, but may also prevent infection and reduce multiplication and shedding of the disease-causing agent [6].

Factors that Affect Immune Response to Vaccines are, the Presence of maternal antibodies; Nature and amount of antigen in vaccine; Route of administration; Presence of an adjuvant; Storage and handling of vaccine; Vaccine age; Nutritional status; Genetics; Co-existing disease [7].

Other vaccines may prevent clinical disease, but not prevent infection and/or the development of the carrier state. In other cases, immunization may be completely ineffective or only able to reduce the severity of the disease. Thus, the decision whether to recommend vaccination as part of an animal disease control strategy requires a thorough knowledge of the characteristics of the disease agent and its epidemiology, as well as the characteristics and capabilities of the various available vaccines. Vaccine purity, safety, potency, and efficacy must be ensured by consistency in the production process. Consistent product quality (batch-to-batch uniformity) must be built in at each stage. Final product testing is used as a check to verify that the controls on the production procedures have remained intact and that the released product meets the specification previously agreed with the licensing authority [8].

Before vaccination, each situation requires evaluation based on the following criteria:

- Risk of disease (anticipated exposure, environmental factors, geographic factors, age, breed, use, and sex)
- Consequences of the disease (morbidity/mortality, zoonotic potential)
- Anticipated effectiveness of the selected product(s)
- Potential for adverse reactions to a vaccine(s)
- Cost of immunization (time, labor and vaccine costs) vs potential cost of disease (time out of competition; impact of movement restrictions imposed in order to control an outbreak of contagious disease; labor and medication if, or when, animals develop clinical disease and require treatment, or loss of life) [3].

5. LIVESTOCK VACCINE PROGRAMMES

Vaccination programs should always be customized for your operation. Items to consider while establishing a vaccination program include: geographic region, type of cattle operation, frequency of introducing new stock, post-vaccination problems and export or interstate shipping requirements. For best results, always follow the manufacturer’s recommendations for dosage, method of administration, number of times given and proper storage. Preventing disease through the use of a herd health management plan saves time and money. For best results, work with a veterinarian who is familiar in field operation. Justifying the cost of preventive management is sometimes difficult. Experiencing a health disaster certainly drives home the point that “announce of prevention is worth a pound of cure” [9].

6. STANDARDIZATION OF VETERINARY VACCINES

Vaccine is a biological preparation that improves immunity to a given particular disease of life. Vaccines have an agent that resembles a disease-causing microorganism, and is produced from weakened or killed forms of the microbe or its toxins. The agent in vaccine stimulates the body's immune system to recognize the agent as foreign and so that the immune system can more easily recognize and destroy any of these micro-organisms which later encounters. Vaccine is the formulations first developed by Edward Jenner's in 1796 within the use of the cow pox vaccine, which administered to humans, provided them protection against smallpox. The principle of vaccination is to induce a primary immune response in the vaccinated subject so that following the exposure of a pathogen; a rapid secondary immune response is generated leading to the accelerated elimination of the organism and protection from clinical disease. Success depends on the generation of memory T and B cells and the presence of neutralizing antibody in the serum [10]. Vaccination is one part of an effective health program as it helps to prevent disease and, in most cases, is more cost-effective than treating sick animals. Veterinarians have succeeded in greatly reducing the incidence of important diseases by taking advantage from improved technologies in vaccines production and by planning vaccination schedules based on the different characteristics of available products. Today, veterinarians can recommend and plan to use vaccines designed for a specific herd or flock or class of animals and even for individual treatments [11].

7. GENERATIONS OF VACCINES

Vaccines are classified into three types based on generation;

7.1 First Generation of Vaccines

The first-generation vaccines are still widely used today. They consist of whole cell organisms, either live or weakened, or killed forms.

7.1.1 Live and weakened/attenuated

These forms of vaccines are great in that they produce both humeral (antibody) and cellular immune responses. The only problem with these is that the pathogen has the potential to revert back into a dangerous form, causing the disease that you can`t protect against.

7.1.2 Killed pathogen

Some vaccines do not carry the same risk of reverting to a dangerous form. They generate an antibody response, but may not generate cellular responses (no T-killer response). Depending on the disease, antibody production may or may not be enough to ward off an infection.

7.2 Second Generation of Vaccines

The second-generation vaccines were created in order to minimize the risks of having the pathogen revert to a dangerous form. The way these vaccines work is that, they do not contain the whole organism, but rather subunits. Subunits may consist of the toxins that the pathogens create (if they are bacterial). Another example of subunit vaccine is that only contain protein sections of the pathogen, such as an acellular form. A great example of a second generation vaccine is DTaP. The vaccine contains diphtheria toxoid, tetanus toxoid, pertussis toxoid, as well as the acellular version of pertussis. As with the issues with the 1st generation of vaccines, the 2nd generation vaccines can generate antibody response and T-helper response, but again, no T-Killer response.

7.3 Third Generation Vaccines

This kind of vaccine is that is being developed for Ebola. There are two different third Generation Vaccines.

7.3.1 Recombinant vector vaccines

Essentially, the antigen included in the vaccine is also a subunit, consisting of DNA. As in the case of the Ebola vaccine, they are including the glycoprotein (GP) shell of the virus. What happens next is that they somehow use the DNA from the GP, and insert it into an adenovirus carrier. The adenovirus now carries the GP DNA, and they use bacteria to grow more of the adenovirus. Other carrier methods use bacteria to carry the target DNA. When viruses infect the body, they infect a cell and replicate using a cell's replication abilities to make copies of it. The idea of including the antigen DNA in an adenovirus is that the adenovirus will make copies of itself along with the pathogen DNA. Because of the immune system will recognize the adenovirus as a pathogen, it will mount a full immune response to the adenovirus and the targeted antigen.

7.3.2 DNA vaccines

Works on a similar process to Recombinant Vector Vaccines, however, they do not use a carrier for replication. The target DNA antigen is inserted into a circular piece of DNA called plasmid. Plasmids are directly injected into the body and the host cells will take up and absorb the DNA sequence. The host cells will then replicate the DNA along with the target DNA antigen, so the cell becomes the antigen-making factory, which therefore stimulates the immune system.

8. VACCINE FORMULATION

While the development and widespread use of effective vaccines has an extraordinary impact on global health, there are many other infectious and diseases for which vaccines are not available. Increasing understanding of the immune system and the nature of particular immune responses that are associated with protection from infections or diseases are being put to use by vaccine developers who now produce increasingly sophisticated vaccine candidates for complex diseases [12]. Many of the newer vaccine candidates are based on protective antigens which are inherently less immunogenic than the whole cell inactivated or live attenuated vaccines or multicomponent conjugate vaccines that were developed in the past [13]. Therefore, adjuvant has become an increasingly important ingredient in novel vaccines being developed today [14]. Vaccines available in the market contain various types of additives [6], antigens and Adjuvants [15] which in combination provide maximum protection against various types of infectious disease. This vaccine contains various types of live or killed viruses, inactivated bacterial toxin and polysaccharides [16]. This diverse nature of antigens requires various types of Excipients to stabilize them. Selection of various types of Excipients is a serious task having huge implication towards their safety, stability and storage. Like any other pharmaceutical Excipients intended for human use, the Excipients used in vaccines must comply with some rigorous standard of quality, purity, availability and compatibility. Pharmaceutical Excipients further evaluated to meet higher purity and safety standard because these are injected into human body and because most commonly used vaccines are administered parenterally. Excipients must comply with strict guideline set by the U.S Food and Drug Administration (FDA) for any vaccine formulation development [17].

Vaccine Additives

Vaccines may contain adjuvant (Immune enhancer) and excipients: Usually inert substances other than the active ingredient included in the manufacturing process of vaccine.

Adjuvants

Adjuvant is a term derived from the Latin word adjuvants are, which means to aid or to help and it was first coined by Ramon in 1926, who observed that horses developed abscesses at the site of an injection of diphtheria toxoid produced higher antitoxin titers than animals without abscesses. In 1926, Glenny demonstrated the adjuvant activity of aluminum compounds utilizing an alum-precipitated diphtheria toxoid [18]. In the mid-1930s, Freund developed a powerful immunologic adjuvant composed of a water-in-mineral oil emulsion containing killed mycobacterium, known as Freund's complete adjuvant (FCA). Adjuvant has traditionally been defined as agents added to vaccine formulations that enhance the immunogenicity of antigens in *vivo*. A proposed update of this definition divides adjuvant into two classes: delivery systems and immune potentiators, based on their dominant mechanism of action. Adjuvants may exert their activities by their impact on the presentation of the antigen to the immune system (e.g. adsorbents, particles and emulsions), the antigen/adjuvant uptake (e.g. emulsions), the distribution (targeting to specific cells), and the immune potentiation/modulation (e.g. microbial, synthetic and endogenous adjuvants) or protection of the antigen from degradation and elimination [19].

8.1 Protein Adjuvant Vaccine

Adjuvants have been defined as agents added to vaccine formulations that enhance the immunogenicity of antigens and induce protection against infection. Vaccines made from live-attenuated or inactivated pathogens can elicit robust protective immune responses because those vaccines contain naturally occurring adjuvants. In contrast, protein-based vaccines in most cases have limited immunogenicity although they have some advantages in terms of safety and cost-effectiveness. Thus, adjuvants are necessary to help these proteins become effective vaccines by inducing strong and long-lasting protective immune responses. The use of appropriate

adjuvants will allow for vaccine formulations that selectively trigger innate immunity and/or adaptive immunity to obtain a desired type of antigen specific immune responses [20].

8.2 Whole Parasitic Vaccine

The parasite used in the vaccine is an early life-cycle stage of the parasite. In the case of parasite vaccine, the level of protection required will vary depending on whether the vaccine is a stand-alone control procedure or is applied in conjunction with management procedures which may reduce exposure to the parasite. Minimizing or eliminating the clinical consequences of infection should be a goal. In general terms, the "performance" requirements for a vaccine are defined on the basis of epidemiological data and mathematical modeling. However, user perception is likely to be very influential. For example, livestock producers are likely to compare a vaccine with control achieved with anthelmintic drugs and ecto-parasiticides, which, when first introduced, approach 100% efficacy. Therefore, the introduction of a vaccine is going to require a sustained educational effort [21].

8.3 Viral Vaccines

Prevention of viral diseases can be achieved by the use of vaccines that induce active immunity or by administration of preformed antibody that provides passive immunity. Currently the available viral vaccines are attenuated live virus vaccines and Killed virus vaccines [22].

8.3.1 Attenuated live virus vaccines

Live virus vaccines utilize virus mutants that antigenically overlap with wild type virus but are restricted in some step in the pathogenesis of diseases. This can be achieved by:

1) Serial passages in embryonated eggs or in cell cultures (usually from a species different from the natural host). This procedure resulted in the chance selection of strains of viruses which have greatly reduced virulence for human (e.g. Measles, Mumps, and Rubella vaccines) [23].
2) Temperature sensitive mutants: grow at low temperature but not at high temperature virus will grow in the cooler upper airways (33°c) where it causes few symptoms and induces antibodies, but it will not grow in the warmer (37°c) lower airways where it can cause pneumonia. e.g. Influenza virus vaccine [24].
3) Cold adaptation: the virus is encouraged to grow at 25°c (e.g. Influenza virus vaccine) [25].
4) Recombinant vaccines (Geneticre-assortment): Recombination by re-assortment only occurs between viruses with segmented genomes e.g. influenza viruses. Cells are co-infected with an attenuated laboratory donor virus and a virulent wild- type influenza virus isolate. The desired re-assortant vaccine virus will contain the surface genes from the wild-type virulent virus and other viral genes that confer attenuation from the attenuated donor virus [22].

8.3.2 Killed virus vaccines

Killed virus vaccines produced by inactivation of viral infectivity whilst retaining its immunogenicity. Purity and potency combined with adequate antigenicity are the key words for inactivated vaccines. Inactivation of viral infectivity is done by Mild formalin, ethylene amines, etc. Killed -viral vaccines are now available either as Whole virus vaccines or Subunit vaccines (purified component vaccines). Subunit vaccines were separated from purified virus by detergent then centrifugation. This vaccine contains only those viral components needed to stimulate protective antibody [23].

8.4 Bacterial Vaccine

Immunization against bacteria presents a particular challenge for DNA vaccines. Unlike viral antigens, the target antigens are proteins that have not necessarily been selected through evolution for efficient expression in eukaryotic cells, and in some instances, are not proteins at all [26].

8.4.1 Killed vaccines

When it is unsafe to use live microorganisms to prepare vaccines, they are killed or inactivated. These are preparations of the normal (wild type) infectious and pathogenic microorganisms that have been rendered non-pathogenic, usually by treatment with using heat, formaldehyde or gamma irradiation so that they cannot replicate at all. Such killed vaccines vary greatly in their efficacy [5].

8.4.2 Live attenuated vaccine

These vaccines are composed of live, attenuated microorganisms that cause a limited infection in their hosts sufficient to induce an immune

response, but insufficient to cause disease. To make an attenuated vaccine, the pathogen is grown in foreign host such as animals, embryonated eggs or tissue culture, under conditions that make it less virulent. The strains are altered to a non-pathogenic form; for example, its tropism has been altered so that it is no longer grows at a site that can cause disease [27]. Some mutants that have a better ability to grow in the foreign host will be selected. These tend to be less virulent for the original host. These vaccines may be given by injection or by the oral route. A major advantage of live virus vaccines is that because they cause infection, the vaccine very closely reproduces the natural stimulus to the immune system [23].

Subunit vaccines

Subunit vaccines contain purified antigens instead of whole organisms. Such a preparation consists of only those antigens that elicit protective immunity. Subunit vaccines are composed of toxoids, subcellular fragments, or surface antigens. Administration of whole organism, as in case of pertussis was found unfavorable immune reactions resulting in severe side effects. The effectiveness of subunit vaccines is increased by giving them in adjuvants. Adjuvants slow antigen release for a more sustained immune stimulation [23].

Conjugate Vaccines

Conjugate vaccines are primarily developed against capsulated bacteria. While the purified capsular antigen can act as subunit vaccine, they stimulate only humeral immunity. Polysaccharide antigens are T independent, and they generate short-lived immunity. Immunity to these organisms requires opsonizing antibodies. Infants cannot mount good T-independent responses to polysaccharide antigens [27].

Recombinant Vaccines

The vaccines are produced using recombinant DNA technology or genetic engineering. Recombinant vaccines are those in which genes for desired antigens of a microbe are inserted into a vector. Different strategies are:

- Using the engineered vector (e.g., Vaccinia virus) that is expressing desired antigen as a vaccine.
- The engineered vector (e.g., yeast) is made to express the antigen, such vector is grown and the antigen is purified and injected as a subunit vaccine.
- Introduction of a mutation by deleting a portion of DNA such that they are unlikely to revert and can create an attenuated live vaccine.
- Live attenuated vaccines can also be produced by assortment of genomes of virulent and avirulent strains.
- Genes coding for significant antigens are introduced into plants, such that the fruits produced bear foreign antigens. This is edible vaccine and is still in experimental stage [27].

9. NEW APPROACHES TO VACCINE DESIGN

Molecular biology and modern technologies are combining to devise novel approaches to vaccine development [27].

9.1 Synthetic Peptides

Viral nucleic acid can be readily sequenced and the amino acid sequence of the gene products predicted. Also, the technology for synthesis of peptides *in vitro* has been refined. It is now possible to synthesize short peptides that correspond to antigenic determinants on a viral protein. The immune response induced by synthetic peptides considerably weaker than that induced by intact protein [23].

9.2 Recombinant Vaccine Virus

The concept is to use recombinant DNA techniques to insert the gene coding for the protein of interest into the genome of a virulent virus that can be administered as the vaccine [27].

9.3 Naked DNA Vaccines

Recombinant plasmids carrying the gene for the protein of interest are injected into hosts and the DNA produces the immunizing protein [23].

9.4 Passive Immunity

Immunity acquired by an individual by the transfer of preformed antibodies. These antibody preparations are often called immune globulins. The main advantage of passive immunity is that it provides immediate protection and the main disadvantage is that it does not provide long term protection. Immune globulin preparations against rabies virus, hepatitis A virus and hepatitis B virus are in common use [27].

10. ADVANTAGES OF VETERINARY VACCINES

Vaccination promotes animal welfare by protecting animal health, but it also has other welfare benefits, e.g. recent investigations have looked at the potential of vaccines in immune-neutering such as immune-castration a humane alternative to the painful traditional methods [28]. Similarly, vaccination can be used during disease outbreaks as a viable alternative to stamping-out, thus avoiding the welfare problems that on-farm mass slaughter can cause. Protecting animal health through vaccination leads to improved animal welfare, and maintaining good welfare ensures that animals can respond successfully to vaccination (as poor welfare can lead to immunosuppression, which can affect the response to vaccination). It is clear that vaccination has tremendous advantages for animal welfare and although the possible side effects of vaccination can have a negative effect on the welfare of some individual animals, the harm caused by these unwanted effects must be weighed against the undoubted benefits for groups of animals [29].

11. CONCLUSION AND RECOMMENDA-TIONS

A vaccine is a biological formulation which improves immunity to a specific or particular disease. Vaccine formulated with an agent that resembles a disease-causing microorganism, and is usually prepared from weakened or killed forms of the microbe or its toxins. Protecting animals from infection is a major obligation of every veterinarian's professional duty in order to preserve animal welfare while assuring human health. Highly infectious animal diseases can reduce the performances of food producing animals and may have a great economical impact on many industries. A reliable supply of pure, safe, potent, and effective vaccines is essential for maintenance of animal health and the successful operation of animal health programmes. Immunization of animals with high quality vaccines is the primary means of control for many animal diseases. Additionally, the Veterinary vaccines are considered as crucial tools in controlling infectious diseases such as brucellosis, rabies, blackleg, anthrax, pasteurellosis and foot and mouth disease that can be transmitted from animals to man, and therefore, are of major concern for public health.

Based on the above conclusion; the following points are recommended;

- The use of vaccine in animals has to be given a considerable attention in order to maintain animal health,
- Both Veterinary and public health professionals should work in collaboration to reduce the incidence and prevalence of zoonotic disease including sharing the experience they have in the control and prevention of zoonosis.
- Government and stakeholders need to have further work for the development of veterinary vaccines including the new vaccine development.

CONSENT

It is not applicable.

ETHICAL APPROVAL

I hereby declare that there are no any experiments that havebeen examined and approved by the appropriate ethics committee in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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