

Development of Vaccine and Diagnostics for Prevention and Control of Transboundary Diseases Globally

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Review Article

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REVIEW

A vaccine is a biological preparation that provides active acquired immunity to a particular disease. Before introduction of vaccination the material from cases of cowpox which was able to prevent smallpox inoculation of smallpox virus, this is called as variolation or heterotypic immunization^[1]. Variolation in china came into existence during 10th century. They implemented a method called as "nasal insufflation" which is administered by blowing powdered smallpox material, usually in scabs, to the nostrils which was popular during 16th to 17th century in china. Edward Jenner in late 1760s understood the concept of protection to fatal disease smallpox to the dairy workers because they already had cowpox^[2]. In 1796, Jenner did one experiment that he took pus from the hand of a milkmaid who was having cowpox, scratched it into the arm of an 8-year-old boy, and six weeks later inoculated (variolated) the boy with smallpox, afterwards it was observed that he did not had smallpox which gave the remarkable startup for development of small pox vaccine and other vaccines^[3].

Vaccine development, vaccinology and immunotherapy in the emergence of providing solution to infectious diseases in man and animals generated visible interest in 20th century. The term vaccine and vaccination started the concept back to the time of Edward Jenner^[2] as a father of vaccinology. The term in Latin "vacca" which means "cow"? "Variola Vaccinia" is first developed by Jenner. Hence being adopted under the vaccination used by friend of Jenner on April 2nd, 1804 later in 1881, Louis pasture a French father of vaccinology presented cholera in human and anthrax in sheep. Thus vaccine terms in the vaccinology came in to existence, by Salk (1914-1975) to develop polio vaccine. Starting with cow pox later small pox used disease free planet first in the world along with other vaccines like. Rubella, Mumps, and Influenza presently Ebola, HIV, Malaria in human and DIVA vaccine concept in veterinary being explored.

Vaccinology developed as a science of "vaccines" from bench to bush and lab to field, provided platform for animal vaccine development, a basis for human vaccine discovery and innovation. Foot and Mouth disease virus (FMD) identified by Loffler in Germany till date vaccine development, improvement, innovation are being understood for disease control after eradication of Rinderpest successfully and declared in 2004 Rinderpest free world by FAO and OIE^[4]. Veterinary vaccines and diagnostics (DIVA) emerged as a solution to control infectious diseases as a most economic tool for major diseases in the transboundary barriers for trades. It also helps nutrition and food security of billion world populations and free flow of livestock to ensure food for all health for all. In the era of antibiotic resistance developed on human population will be difficult in future for treatment, chemical residue, toxicity of food animal for consumption mainly senior citizens, baby and pregnant women globally. Therefore Mastitis vaccines and other combination vaccine are on the way for preventing microbial load in billion populations of man and animal.

The immune system is responsible for defending the body in a safe and efficient way against number of potentially dangerous materials including toxins and infectious organisms. There are many ways to this defense system. Mechanical and biological barriers help to prevent the penetration of exogenous materials into the body. The immune system comes in to role only after these barriers have been breached and cells have been directly attacked. Certain immune cells by variety of mechanism can

directly phagocytose and destroy many pathogens. The close cooperation of the somatic cells, which alert the immune system through alarm signals and then later participate in the effector phase which is called as “stress signals.” This will be nonspecific immune response nothing but innate immune response. Keratinocyte, epithelial cell, hepatocyte, glial cells and fibroblasts, are also involved in innate immunity. In response to stress signals, these cells stimulate release of a variety of messengers which attract and activate phagocytic Antigen-Presenting Cells (APC) which leads to initiate the specific immune response. After activation, APC carry processed foreign antigens from the site of injury and migrate to regional lymph nodes via lymphatics, where they secrete chemokines to attract CD4 and CD8 T cells. The APC present the foreign antigen peptide to these T cells. The naive cells which recognize the foreign peptide on the basis of their receptor structure are stimulated and differentiated into blast cells which now express different surface antigens that make them capable of responding to growth factors, leaving the lymph nodes and themselves secreting cytokines. Clonal proliferation is important to ensure that enough cells are available to react against infectious agent. Activated T cells interact closely in the lymph nodes with B cells, which give them signals for immunoglobulin production. At last they leave the lymph nodes and return to the initial site of injury [5].

The vaccine is mainly composed of antigen and adjuvant in case of veterinary vaccine. The integrity of the vaccine will be maintained with different stabilizers and preservatives as like Thiomersal or Human Serum Albumin. Sodium Thiosulphate, Saponin Antifoam along with so many other constituents will constitute the vaccine. Most of the veterinary viral vaccines will be developed by using cells as a substrate and then it will grow, infected, harvested, clarified and then formulated as a finished product. The development of bacterial vaccine will be done by growing the selected organism on selective medium and then it is formulated by using the mineral oil or aluminum hydroxide gel as an adjuvant.

The Human vaccination programme is also being taken up in India widely and across the globe. The type of the vaccine need to be given will depend on the age groups of the individual which can be mainly divided into neonates, young children's, adolescents, for elderly people and for particular target groups (like Travelers, People exposed to occupational risks etc.). The vaccines which can be given from the Birth to 15 months of age includes Hepatitis B Vaccine, Rota Virus Vaccine, Diphtheria Vaccine, Tetanus and Pertussis Vaccine, Haemophilus Influenza Vaccine, Pneumococcus vaccine, Polio Virus Vaccine, Influenza Vaccine, Measles Vaccine, Mumps Vaccine, Rubella vaccine, Varicella Vaccine, Human Papilloma virus vaccine and Meningococcal vaccine. The vaccines need to be given according to different numbers of doses as per timeline. Elder peoples will need some more types of vaccine even they have been vaccinated during child or adult like which includes Influenza (Flu), Shingles (Herpes Zoster), Diphtheria, Tetanus, Pertussis (Whooping cough) and Pneumococcal diseases like pneumonia. The migration from one country to another is the potential source of the transmission of the disease hence International travelers need to get vaccinated for nothing but same vaccines as being done at the age of children and adult which is nothing but Diphtheria, Hepatitis B, Haemophilus Influenza type B, Human Papillomavirus, seasonal Influenza, Measles, Mumps and Pertussis along with Cholera, Hepatitis A & E, Japanese Encephalitis, Meningococcal Disease, Rabies, Tick borne Encephalitis, Typhoid Fever and Yellow Fever. The personnel's working in particular occupation need to get vaccinated specifically in case of zoonotic organism as like Rabies, Brucella etc [6].

Foot and Mouth disease (FMD) is most economically important and remain major cause of morbidity and mortality worldwide. The three critical elements of FMD vaccine production are antigenic production, inactivation and adjuvant. FMDV antigen production was the transition to tissue culture suspension in bioreactor and virus growth being produced in India as a trivalent vaccine comprising of Type O (IND R2/75), Type A (IND 40/2000) and Type Asia 1 (IND 63/72) tissue cultured inactivated oil and gel vaccine [7,8]. FMD is devastating disease having economic loss of INR 25000 Crore (5 billion USD) for one economic year (Times of India News). FMD CP (Foot and Mouth Disease- Control Programme) launched by government of India in states covered around 85 million animal population in first phase through 300 millions of trivalent vaccine which is being enhanced to 500 million animals during 12th five year plan with allocated budget of INR 500 Crore by 2020 [9-11].

The new generation vaccine with newer technology includes recombinant vaccine; capsid vaccine and development of it will guide scientific discovery and innovations for transboundary diseases which is barrier of trade in economic development worldwide.

The “stamping out” policy is being practiced in European countries which is not practical in India Hence European economic recommendation of choice “vaccinate to live” which means “Prevention is better than cure” and vaccine strategy is for “living not killing the animals” which appears to be most relevant to Indian subcontinent. The new generation vaccine like Subunit vaccine, DNA vaccine, Live vector vaccine, Synthetic peptide vaccine, Marker vaccine, DIVA vaccine, Empty Capsid vaccine, Plant made or edible vaccine, engineering of infectious clones for novel vaccines etc. The vaccination is economically important tool against the treatment. The broad antigenic average with optimal vaccine can take as a vaccine bank with a specific adjuvant and antigenic comparison as a immune potentiator to the antigen presenting cell (APC) in the immune mechanism to ensure protection against diseases like Blue Tongue disease, Johne's Disease, Salmonella, Swine fever, Sheep pox, Goat pox, Hemorrhagic Septicemia (HS), Black Quarter (BQ), Enterotoxaemia (ET), Foot rot, Mastitis, and other combination vaccines. The vaccines for parasitic diseases are on the way of development.

Blue tongue Pentavalent Tissue Culture inactivated vaccine containing BHK21 adapted Blue Tongue virus 1 BTV1, BTV2, BTV10, BTV16 and BTV 23 with oil and gel as an adjuvant [12]. Johne's disease vaccine is the first indigenous vaccine against Johne's disease affecting ruminants. The bacterial genome was completely sequenced and highly related to ‘Bison’ type. The vaccine consists of suspension of the S5 Indian Bison type strain of Mycobacterium Avium Subspecies Paratuberculosis (MAP) inactivated by physical method and adjuvanted with mineral oil or Aluminium hydroxide gel.

The vaccines which are under pipeline of development include for humans Alzheimer Disease which helps in stimulation of antibodies against amyloid-beta Protein and removes it from brain and helps to get immunized against it. A live attenuated *Listeria Monocytogenes* based vaccine is under development for the women who already have cervical cancer caused by Human Papillomavirus. A therapeutic vaccine in development is targeting low mutating part from protein p24 of HIV virus. A monoclonal antibody vaccine in development targets influenza infections. Development of a rodent model of mammalian malaria which allowed production of all stages of the malaria parasite for study was helpful for the development of the vaccine. Studies with sporozoites which is the stage of mosquitoes in their saliva helped to demonstrate that immunization with radiation-attenuated sporozoites could produce a solid, sterile immunity both in mice and Humans. Immune mechanism of the vaccine involve anti sporozoite antibodies which immobilize sporozoites injected into the skin by mosquitoes, followed by CD4+ and CD8+ T-cells acting against liver stage parasites produced by sporozoites that have escaped antibody-based immunity and invaded hepatocytes. Immunization with intact, attenuated sporozoites and immunization with "sub-unit" vaccines based on immunogenic components of sporozoites or liver stage parasites are two different alternatives are being used for vaccine development ^[13].

Vaccine development and testing involves basic research, clinical studies, side effects and adverse reactions. The general stages of the development of new vaccines constitute exploratory stage, Preclinical stage, clinical development, regulatory review and approval, manufacturing and quality control. The testing of vaccine is carried through serial tests in quality control which involves sterility, safety, potency. Apart from this there are many other tests which will be carried out as per the specifications and type of vaccine. The vaccine safety is the main test of the vaccine which needs to be complied for each and every batch of vaccine produced on animal models or voluntary humans.

Economic aspects of vaccine relates with cost analysis, cost-benefit analysis, cost effectiveness analysis, and cost-utility analysis. Immunization is an excellent investment which is highly cost-effective and usually cost-saving for vaccines that are currently recommended for global use. Even though prices of new generation vaccines are more than prices of traditional vaccines, they are still highly cost-effective. The World Health Organization, UNICEF, and vaccine manufacturers have developed alternative approaches to make newer vaccines available to developing countries at reduced prices. A consistent immunization program without support is an increasingly important goal of the country. However, external support will be essential in the short term to ensure that the entire world's people benefit fully from the new vaccines to avoid the deadly infections of the diseases ^[14].

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