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Vishweshwar Kumar Ganji
FMD Research Lab, Indian Veterinary Research Institute, Bengaluru, Karnataka, India

Mallesh Pottabathula
Department of Veterinary Parasitology, CVSc, PVNR Telangana Veterinary University, Hyderabad, Telangana, India

Sampath Kontham
Department of Agb, CVSc, PVNR Telangana Veterinary University, Hyderabad, Telangana, India

Pruthvi raj boga
Veterinary Assistant Surgeon, PVC, Peddakondur, Bhongir, Telangana, India

Correspondence
Vishweshwar Kumar Ganji
FMD research lab, Indian Veterinary Research Institute, Bengaluru, Karnataka, India

Foot-and-mouth disease and vaccination

Vishweshwar Kumar Ganji, Mallesh Pottabathula, Sampath Kontham and Pruthvi Raj Boga

Abstract
Foot and mouth disease is an infectious and highly contagious viral disease of domestic and wild cloven-hoofed animals. Vaccination is a major means to control FMD in most endemic areas. Current FMD vaccines are typically produced by inactivation of cell culture virus with binary ethylenimine and formulated with oil adjuvant. This vaccine has a subset of limitations such as requirement for frequent booster doses, poor cellular response, improper inactivation of virus. The focus has been shifted for production of an alternative, more desirable vaccine formulations like live attenuated vaccines, live vectored vaccines, DNA vaccines, subunit vaccines, virus like particles *etc.*, which are achieved through rDNA technology.

Keywords: FMD, vaccination, VLP, subunit, alternate vaccines

Introduction
Foot and mouth disease is an infectious and highly contagious viral disease of domestic and wild cloven-hoofed animals causing a huge economic loss in agriculture worldwide [1]. As per the latest ICTV virus taxonomy release the etiological agent, FMD virus was grouped under the genus *Apthovirus* of family *Picornaviridae* [2]. FMD was first recognised by a Francisian monk Hieronymus Fracastorius (1546) in cattle [3], and Loeffler and Frosch (1897) [4] demonstrated for the first time a filterable agent causing animal disease, FMD [4].

History of vaccination in FMD
Vaccination is a major means to control FMD in most endemic areas [5]. In 1927 Belin for the first time described his experiments with attenuation of the virus [6]. The first practical vaccine against FMD relied on Formalin inactivated virus obtained from tongue epithelium of infected cattle [7]. Frenkel (1947) used bovine tongue epithelial cells for growing virus [8]. The use of suspension cultures of BHK cells was found to support the growth of virus at Pirbright laboratory [9].

Current vaccines and the pitfalls
Today, most FMD vaccines are typically produced by inactivation of virus generated in suspension cell cultures with binary ethylenimine and formulate with an oil based adjuvant [10]. There are several limitations of current vaccine, such as short duration of immunity typically only lasts for six months, requirement for frequent booster doses, poor cellular response, improper inactivation of virus [11]. Further inability to differentiate infected recovered animals from vaccinated animals lead to focus on designing improved vaccines.

Improved alternate vaccines
The research went on for production of more desirable vaccine formulations like live attenuated vaccines, live vectored vaccines, DNA vaccines, subunit vaccines, virus like particles *etc.*, which are achieved through rDNA technology. Interestingly studies reported that 141 to 160 epitope peptide of VP1, so called 'FMDV loop' [12, 13] could induce not only neutralizing antibodies but also FMDV specific T cells [14] but the problem is it alone cannot induce sufficient neutralizing antibodies to ensure immunity against FMD [15]. Further the researchers developed several subunit vaccines using VP1, either isolated from purified virus or produced by recombinant DNA technology [16], the use of VP1-derived peptides [12] or chemically synthesized VP1 peptides [17], the use of live vectors expressing VP1 fusion proteins [18], inoculation with DNA expressing VP1 epitopes alone [14] or co-administered with DNA encoding IL-2 [19], and use of transgenic plants expressing the entire VP1-coding region

or plants infected with a recombinant tobacco mosaic virus expressing VP1 [20]. All of these strategies present a limited subset of viral immunogens to the vaccinated animal, and although they often induce high titers of neutralizing antibodies, protection against virus challenge in livestock was questionable. The guinea pigs challenged after vaccination with recombinant P1 polyprotein expressed in *Pichia pastoris* shown protective immune response [21]. Calcium phosphate nanoparticle prepared with FMDV P1-3CD gene construct protected mice and guinea pigs against virus challenge [22]. Long lasting protective immune response was seen in guinea pigs by cationic PLG micro particle based delivery of DNA vaccine construct pVAC-1D [23]. The vaccine comprising an adjuvanted formulation of replication deficient Ad5 engineered to encode the FMDV structural proteins VP0, VP1 and VP3, alongside the viral protease 3C required for their cleavage from the polyprotein was used as a novel viral vector vaccine [24]. Efficacy studies of different vaccines in cattle showed protection from as early as 7 days post vaccination following a single immunization [25]. The VLP based FMD vaccines produced in baculovirus expression system, and by a replication deficient human adenovirus vector based system are reported to be successful recombinant vaccine candidates in protecting the target species against FMDV challenge [26]. Many attempts were made to increase the stability of the empty capsids by genetically engineering the capsid [27-29].

References

1. Kandeil A, El Shesheny R, Kayali G, Moatasim Y, Bagato O, Darwish M *et al*, Characterization of the recent outbreak of foot-and-mouth disease virus serotype SAT2 in Egypt. Archives of virology. 2013; 158(3):619-627.
2. ICTV. 2015. Virus taxonomy: 2015 release http://www.ictvonline.org/virus Taxonomy.asp
3. Fracastorius H. De sympathia et antipathia rerum liber unus. De contagione et contagiosis morbis et eorum curatione liber I, Venice, Heirs of LA Junta. 1546.
4. Loeffler F, Frosch P. Summarischer Bericht über die Ergebnisse der Untersuchungen der Kommission zur Erforschung der Maul-und Klauenseuche bei dem Institut für Infektionskrankheiten in Berlin. Dt Med Wschr. 1897; 98:80-84.
5. Li Z, Yi Y, Yin X, Zhang Z, Liu J. Expression of foot-and-mouth disease virus capsid proteins in silkworm-baculovirus expression system and its utilization as a subunit vaccine. PLoS One. 2008; 3(5):2273.
6. Belin M. Premiere tentative de vaccination antiaphteuse réalisée al'aide des complexes vaccino-aphteux. CR Soc. De Biologie Paris. 1927; 96:116.
7. Waldmann D, Kobe K, Pyl G. Die aktive Immunisierung des Rindes gegen Maul-und Klauenseuche. Zentralbl. Bakteriol., Orig. 1937; 138:401.
8. Frenkel HS. La culture du virus de la fièvre aphteuse sur l'épithelium de la langue des bovidés. Bull. Off. Int. Epiz. 1947; 28:155-162.
9. Capstick PB, Garland AJ, Chapman WG, Masters RC. Production of foot-and-mouth disease virus antigen from BHK 21 clone 13 cells grown and infected in deep suspension cultures. 1965, 1135-1136.
10. Rodriguez LL, Gay CG. Development of vaccines toward the global control and eradication of foot-and-mouth disease. Expert review of vaccines. 2011; 10(3):377-387.
11. Parida S. Vaccination against foot-and-mouth disease virus: strategies and effectiveness. Expert review of vaccines. 2009; 8(3):347-365.
12. Strohmaier K, Franze RT, Adam KH. Location and characterization of the antigenic portion of the FMDV immunizing protein. Journal of General Virology. 1982; 59(2):295-306.
13. Pfaff EMBO, Mussgay M, Böhm HO, Schulz GE, Schaller H. Antibodies against a preselected peptide recognize and neutralize foot and mouth disease virus. The EMBO journal. 1982; 1(7):869.
14. Wong HT, Cheng SCS, Chan EWC, Sheng ZT, Yan WY, Zheng ZX.*et al*, Plasmids encoding foot-and-mouth disease virus VP1 epitopes elicited immune responses in mice and swine and protected swine against viral infection. Virology. 2000; 278(1):27-35.
15. Chen W, Liu M, Jiao Y, Yan W, Wei X, Chen J. *et al*, Adenovirus-mediated RNA interference against foot-and-mouth disease virus infection both in vitro and in vivo. Journal of virology. 2006; 80(7):3559-3566.
16. Kleid DG, Yansura DG, Heyneker HL, Miozzari GF, Genentech, Inc. Method of altering double-stranded DNA. U.S. Patent. 1987; 4:663-283.
17. Nargi F, Kramer E, Mezencio J, Zamparo J, Whetstone C, Van Regenmortel MHV *et al.*, Protection of swine from foot-and-mouth disease with one dose of an all-D retro peptide. Vaccine. 1999; 17(22):2888-2893.
18. Kit M, Kit S, Little SP, Di Marchi RD, Gale C. Bovine herpesvirus-1 (infectious bovine rhinotracheitis virus)-based viral vector which expresses foot-and-mouth disease epitopes. Vaccine. 1991; 9(8):564-572.
19. Wong HT, Cheng SCS, Sin FWY, Chan EWC, Sheng ZT, Xie Y. A DNA vaccine against foot-and-mouth disease elicits an immune response in swine which is enhanced by co-administration with interleukin-2. Vaccine. 2002; 20(21):2641-2647.
20. Wigdorovitz A, Filgueira DP, Robertson N, Carrillo C, Sadir AM, Morris TJ *et al*, Protection of mice against challenge with foot and mouth disease virus (FMDV) by immunization with foliar extracts from plants infected with recombinant tobacco mosaic virus expressing the FMDV structural protein VP1. Virology. 1999; 264(1): 85-91.
21. Balamurugan V, Renji R, Venkatesh G, Reddy GR, Nair, SP, Ganesh K *et al.*, Protective immune response against foot-and-mouth disease virus challenge in guinea pigs vaccinated with recombinant P1 polyprotein expressed in Pichia pastoris. Archives of virology. 2005; 150(5):967-979.
22. Joyappa DH, Kumar CA, Banumathi N, Reddy GR, Suryanarayana VV. Calcium phosphate nanoparticle prepared with foot and mouth disease virus P1-3CD gene construct protects mice and guinea pigs against the challenge virus. Veterinary microbiology. 2009; 139(1):58-66.
23. Reddy KS, Rashmi BR, Dechamma HJ, Gopalakrishna S, Banumathi N, Suryanarayana VV *et al*, Cationic microparticle [poly (d, l-lactide-co-glycolide)]-coated DNA vaccination induces a long-term immune response against foot and mouth disease in guinea pigs. The journal of gene medicine. 2012; 14(5):348-352.
24. Robinson L, Knight-Jones TJD, Charleston B, Rodriguez LL, Gay CG, Sumption KJ *et al*, Global Foot-and-Mouth Disease Research Update and Gap Analysis: 3-Vaccines. Transboundary and Emerging Diseases. 2016; 63(1):30-41.

25. Moraes MP, Diaz-San Segundo F, Dias CC, Pena L, Grubman MJ. Increased efficacy of an adenovirus-vectored foot-and-mouth disease capsid subunit vaccine expressing nonstructural protein 2B is associated with a specific T cell response. Vaccine. 2011; 29(51):9431-9440.
26. Guo HC, Sun SQ, Jin Y, Yang SL, Wei YQ, Sun DH. Foot-and-mouth disease virus-like particles produced by a SUMO fusion protein system in *Escherichia coli* induce potent protective immune responses in guinea pigs, swine and cattle. Veterinary research. 2013; 44(1):1.
27. Mateo R, Luna E, Rincón V, Mateu MG. Engineering viable foot-and-mouth disease viruses with increased thermostability as a step in the development of improved vaccines. Journal of virology. 2008; 82(24):12232-12240.
28. Porta C, Xu X, Loureiro S, Paramasivam S, Ren J, Al-Khalil T. Efficient production of foot-and-mouth disease virus empty capsids in insect cells following down regulation of 3C protease activity. Journal of virological methods. 2013; 187(2):406-412.
29. Kotecha A, Seago J, Scott K, Burman A, Loureiro S, Ren J.Structure-based energetics of protein interfaces guides foot-and-mouth disease virus vaccine design. Nature structural & molecular biology. 2015; 22(10):788-794.
30. Eman M EL-Rawy, Afaf A Khader, Manal S Mahmoud, Eman SA Zaki, Selim S Salma, Wafaa S Abd El-Moneim, Abeer Mwafy. Preparation and evaluation of combined oil adjuvant vaccine against duck pasteurellosis and *Riemerella anatipestifer* infection in ducks. Int J Vet Sci Anim Husbandry 2020;5(1):18-21.