Points to consider in the prevention, control and eradication of FMD

Dr. Paul Sutmoller and Dr. Simon Barteling***

*Animal Health Consultant, Former Chief of Laboratories of the Panamerican FMD Center, PAHO/WHO
USA: 1502 Largo Road #101, Richmond, VA 23233,
The Netherlands: Duinschooten 12 bungalow 127, 2211 ZC Noordwijkerhout
E-mail: paulsutmoller@compuserve.com

** Simbar Consultancy, previously occupied at ID-Lelystad, The Netherlands as Head Dep. FMD Vaccine Development, Research and Production and as Head Community Co-ordinating Institute (for the EU).
Present address: Nieuwe Keizersgracht 438, 1018 VG, Amsterdam
E-mail: simbar@scarlet.nl

Rationale risk management for the prevention, control and eradication of FMD must be carried out on science-based risk assessments. Presently, the discussion on "to vaccinate or not to vaccinate", and its consequences for international trade, relates to the fact that vaccinated animals may - like convalescent or subclinical infected animals - become (virus) carriers. Also, the argument is used that vaccinated animals will have antibodies against FMD and that this might obscure the tracing of the disease.

But, how large is that risk of creating vaccinated carriers and what would be the risk posed by such animals? Does that risk justify the zero-risk approach of "stamping-out" or the killing of all vaccinated livestock? Are these measures really assuring zero-risk?

For assessments of such risks all of the relevant science must be used. With this in mind, we have made an exhaustive review of scientific literature published over the past 50 years. Each of the following statements is sustained by literature references and our own experience gained in many years of FMD research on pathogenicity, epidemiology, vaccine technology both in the laboratory and in the field.

The statements as compiled are divided under the sub-headings:

- Dissemination of FMD;
- Carriers;
- Carriers and vaccination;
- Vaccines;
- Control and eradication by vaccination;
- Trade in animals and animal products;
- Prevention, control and eradication of FMD.

Dissemination of FMD

1. Among all species, cattle produce, in general, the greatest total amount of infectious virus particles and, therefore, are the major source for the spread of FMD. The number of infectious units excreted by cattle can easily surpass 10^{10} (10 billion).
2. Aerogenic spread in the preclinical stage is over-emphasised; the main control effort must be on the prevention of virus escape from infected premises, once discovered.

Preliminary disinfecting – as good as possible - should come first. Then cleaning and disinfecting of premises and holding facilities, trucks and equipment must be carried out with great care and in a way to prevent the formation of aerosols. High pressure sprays, very likely, will generate large amounts of (infectious) aerosols and, therefore, should be omitted unless it has been proven that disinfectants added to the spray do their job.

3. The total amount of infectious virus from aerosols, saliva, lesion tissue, urine, faeces, and milk is at least one magnitude higher for cattle than for pigs and is several magnitudes higher for cattle than for sheep.
4. Before clinical signs occur, pigs excrete - in general - larger amounts of virus aerosols than other species do, at least if the virus is well adapted to pigs
5. In small ruminants, lesions in the acute stage of FMD are often difficult to discern and consequently, FMD can easily cross borders by international trade of sheep with sub-clinical disease. However, if not moved, transported, or marketed the role of sheep in the spread of FMD is minor. The same counts for wildlife.
6. People are efficient mechanical transmitters of FMD. During outbreak situations, close contact of people with susceptible animals, such as those performing inspection of the mouth, is particularly risky. Therefore, they must apply rules for bio-security with the greatest care even if clinical signs of FMD were not detected
7. Any person (veterinarians, farmers, sanitary and digester personnel etc.) who has had contact with infected animals or carcasses must take strict bio-security measures in order to avoid the transmission of FMD.
8. Massive killing and disposal cannot be carried out with sufficient bio-security and, therefore, represents a high risk of spreading FMD.

Carriers

9. In a general epidemiological sense the term “carrier” is assigned only to those animals that are able to disseminate an infection, yet remain clinically without symptoms of the disease. However, transmission of FMD is anecdotal and has never been convincingly demonstrated. In the present points the term “carrier” is used, but with the understanding that this does not imply that such animals are contagious.
10. The carrier status often occurs in FMD convalescent domestic animal species. The duration of the carrier status depends on the individual animal, animal species, and virus strain. Among the domestic species the largest number of carriers occurs in cattle, followed by sheep and goats. Pigs do not become carriers. Camelids are not easily infected, hardly disseminate virus and do not carry the virus to any extent and, therefore, do not play a significant epidemiological role.
11. Animals recovered from FMD, or after sub-clinical infection, may still carry some virus in their throats. Also, vaccinated (protected) animals in a heavily infected environment may become a virus carrier. Under normal circumstances carriers do not excrete virus and FMD virus cannot be detected in the environment of the carrier.
12. Over the past hundred years there are only a few documented cases where (convalescent) carrier cattle probably played a role in the introduction of FMD into FMD-free herds. Such cases are not known for vaccinated carriers.

13. The risk that carrier livestock transmit FMD to susceptible livestock by direct contact is very low. Even after severe stress carriers did not transmit disease. The risk that a carrier produces sufficient virus aerosol to transmit disease is negligible or close to zero.

Carriers and vaccination

14. Vaccination by itself cannot cause the carrier status (FMD vaccine is a "killed", safe vaccine). A vaccinated animal must be exposed to a quantity of FMD virus to become a carrier. When a (convalescent) carrier is vaccinated it is likely to remain a carrier.
15. Vaccination suppresses the amount of FMD virus (released or discharged) in the environment (low morbidity!) which makes it unlikely that (new) carriers will be induced in vaccinated herds.
16. Carriers among vaccinated cattle have not caused FMD outbreaks among susceptible non-vaccinated livestock populations like sheep, nor have they hampered FMD eradication efforts.
17. Virus infection raises antibodies against the virus particle and against non-structural proteins, the proteins that are needed for virus multiplication. Antibodies against non-structural proteins are useful indicators of a past infection. Animals with such antibodies are potential carriers.
18. Tests to detect antibodies against non-structural proteins are not 100% sensitive in individual animals, but perform very well if used for screening on a herd basis. If required, individual animals can further be tested for presence of virus e.g. by probang tests or PCR . Tests to discriminate between carriers and vaccinated animals have been widely used and the results are internationally accepted.
19. Vaccines prepared from purified FMD antigens - like those in the international vaccine banks – will raise antibodies to the virus particle only and will not raise antibodies against non-structural proteins. Therefore, such vaccines - in combination with tests for antibodies against non-structural proteins - will perform like a "marker" vaccine, enabling discrimination between animals that are vaccinated only and vaccinated animals that had been infected as well (potential carriers).
20. If a FMD outbreak is controlled by vaccination, testing for non-structural proteins of vaccinated livestock contributes - for trade purposes - to further reduction of any risk. A statistical valid serological survey of the surveillance zone around the vaccination zone for (FMD-) type specific antibodies further reduces the risk of hidden FMD.

Vaccines

21. For vaccine production, rules for good manufacturing practice must be applied and quality control must be performed during each of the production steps as well as a rigorous safety and potency control of the final product. The latter must be carried out by an independent institution.
22. Vaccines used for emergency vaccinations must be formulated from purified antigen from which the non-structural proteins have been removed. Such vaccines will raise antibodies against the virus particle only and not against the non-structural proteins.

Control and eradication by vaccination

23. Early protection afforded by both aqueous aluminum hydroxide-saponine vaccines and oil-adjuvant vaccines permit their use as emergency and ring vaccination in the face of an outbreak. Protection will be afforded already between 4-6 days after vaccination. All susceptible species can successfully be protected with both types of vaccine with the exception of pigs. Pigs can be well protected with oil-adjuvanted vaccines.
24. Both types of vaccines protect cattle of different breeds very effectively against the disease under a variety of epidemiological, ecological and management conditions. Oil adjuvant vaccine produces, in general, a longer lasting immunity than aqueous vaccines. Cattle up to 2-years should be vaccinated every 6 months, thereafter, a yearly vaccination will maintain their immune status.
25. Since 1990 the FMD control programs of all the countries of South America have successfully used the oil-adjuvant vaccines for the systematic vaccination of cattle. The vaccine is cost-effective, does not produce any undesirable side effects, and is well accepted by the farmers and livestock industry.
26. Sheep can be very well protected by both aqueous and oil-adjuvant vaccine with long lasting immunity induced by the latter type of vaccine. However, vaccination of sheep was not included in European and South American systematic vaccination programs. In general, systematic vaccination of pigs is not recommended. However, it can be used strategically in high-risk areas.

Trade in animals and animal products

27. Importing live animals from a country with the status "FMD free without vaccination" is not risk free. Importation from a country with an active FMD prevention and control program e.g. with sound vaccination may be a lot less risky.
28. The presence of neutralizing antibodies in meat, lymphnodes and bone marrow, is the best guarantee that the carcass is free of FMD virus. Special treatment of meat (e.g. sterilization) from vaccinated animals cannot be justified.
29. The risk of mechanical contamination of a cattle carcass or organs with 'carrier virus' from the pharyngeal area during slaughter and processing is negligible or close to zero.
30. After an (undetected) outbreak the risk of dissemination of FMD virus by contaminated milk is high. The probability of dissemination of FMD virus by milk from well-vaccinated herds is close to zero.
31. The importation of milk and milk products from countries with a high level of herd immunity, poses – because of the presence of antibodies - a close to zero or negligible risk.

Prevention, control and eradication of FMD

32. Primary infections in FMD free countries have frequently involved pigs, often on swill feeding holdings. Swill from ships and aircrafts form a special threat in this respect. Therefore, swill feeding practices are not compatible with a FMD-free status

unless the swill is processed in officially validated plants that are well controlled by the government.

33. During the past twenty years at two occasions FMD virus escaped from technically well-equipped high-containment laboratories causing outbreaks outside the facilities. Therefore, regular (international) inspection is needed on the status of facilities and equipment, on logistics, and on the execution of the internal control on biosafety of FMD laboratories and vaccine production plants. This is in particular important for such laboratories in countries with an FMD-free status.
34. Dissemination of FMD in a country with a susceptible livestock population by the action of terrorists does not seem unrealistic. The virus can rather easily be obtained and spread in a target country. The availability of large internationally managed vaccine banks, containing a wide variety of antigens, and rapid application of vaccines is the best way – if not the only way – for countries to prevent complete disasters. Contingency plans must incorporate such possibilities.
35. In traditionally FMD free countries, stamping-out is the first choice to eradicate the disease. Systematic vaccination is not indicated, but ring vaccination must be included in any contingency plan. International vaccine banks are established for that purpose. During (emergency) vaccination operations bio-security must be strictly maintained. If possible, ring vaccination of the livestock in the immediate vicinity of the outbreak farm must be carried out before the removal of the carcasses.
36. Ring-vaccination should be carried out including all susceptible species without delay. Preferably, the vaccination must be carried out from the outside of the "ring" towards the outbreak farm. Simultaneously, vaccination must proceed from the center towards the outside, to protect as soon as possible the most endangered farms. In the immediate vicinity of the outbreak farm, the large holdings should be vaccinated first because potentially those are the largest "aerosol samplers".
37. Europe and several countries in South America became free of FMD by systematic vaccination of their cattle only. Then they obtained the "FMD free status" and ceased vaccination. They were able to maintain that status for a considerable period of time.
38. The huge susceptible cattle population in those FMD free regions in combination with
    - the loss of experience and knowledge concerning the prevention, control and eradication of FMD,
    - the "open border" policy
    - increased trade and travel,

    created favorable conditions for the re-introduction of FMD e.g. in the UK, the Netherlands, and South America.
39. In the Netherlands the 2001 outbreak was –in the end - quickly controlled by the vaccination of all livestock in the infected area. The slaughter of all vaccinated animals was a decision made for economic (export) reasons.
40. Computer models used to predict the spread of FMD can be a useful tool, but the results of the simulations must be interpreted with extreme caution. In the UK - and in The Netherlands at the beginning of the outbreak - computer models, which had not been validated by practical experience, guided the eradication measures. This lead to "circle" stamping-out of supposed contacts and to create a "fire corridor". However, FMD virus does not spread in mathematical circles and livestock on many farms were killed unnecessary.

41. In Uruguay a FMD outbreak as extensive as in the UK was - without massive stamping-out - quickly brought under control by the restriction of livestock movements and massive vaccination of the cattle population of approximately 10 million cattle. As in the past, vaccination of the nearly 13 million sheep was not required to control and eradicate the disease.
42. Re-introduction of general vaccination of the cattle in Europe is not necessary provided that contingency plans include adequate infrastructure of veterinary services, logistics, and the availability (from vaccine banks and production facilities) of large quantities of vaccine.
43. Over the past 10 years many outbreaks of FMD have been rapidly controlled by vaccination of susceptible livestock in the outbreak area. To reduce the risk of re-introduction of FMD, emphasis must be on the reduction of FMD outbreaks world-wide. In endemic countries, systematic vaccination of the cattle population is the tool in the struggle against FMD and should be stimulated and/or supported financially by international co-operation.
44. International cooperation has been a major instrument in the struggle against the disease. A global approach towards FMD control and eradication is more needed then ever.