



Review article

Recurrent appearance of foot and mouth disease virus (FMDV) in Saudi Arabia

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ABSTRACT

There are seven immunologically distinct serotypes of FMDV (O, A, C, Asia 1, SAT 1, SAT 2 and SAT 3), most of them were detected and identified in different regions of Saudi Arabia. FMDV serotype O was the most frequent strain in last decade. Outbreaks of FMDV repeatedly occur among cattle, sheep and goats in various regions of Saudi Arabia during years 1994, 1995, 2000, 2004, 2005, 2006, 2008 and 2010. Recently, 14 (0.78 %) suspected cases of FMDV out of inspected 1800 cows were observed and recorded during Hajj season 1432 H (2011) in Makkah. Prevention and control strategies of FMD in Saudi Arabia particularly during Hajj seasons were discussed.

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1. Introduction

Foot-and-mouth disease (FMD) virus (family Picornaviridae, genus Aphthovirus) is a small RNA virus that causes a highly infectious disease affecting up to 70 species of cloven-hoofed mammals (Hedger, 1981). It spreads very quickly if not controlled. It is present in many countries of the world and outbreaks also periodically occur in disease-free areas. The disease causes fever followed by the development of blisters mainly in the mouth and on the feet (Domingo and Sobrino, 2004).

There are seven immunologically distinct serotypes of FMDV (O, A, C, Asia 1, SAT 1, SAT 2 and SAT 3) and antigenic variation within a serotype can be such that vaccines must be carefully matched to outbreak strains to ensure efficacy (Samuel and Knowles 2001). In addition, within a given serotype there are many immunologically

related sub-types, particularly among the A, O and C (i.e. A₅, A₂₄, C₁, O₁, etc), totaling more than 60 type-subtype known combinations. The high number of FMDV sub-types is the result of error-prone replication of RNA viruses. New variants of FMDV can be the result of homologous recombination between 2 different strains of FMDV. The combined result of the genetic variation of FMDV through mutations, recombinations and selection is that new FMDV variants are constantly being generated with important implication for the selection of FMDV vaccine strains (United States Animal Health Association, 2008).

Saudi Arabia imports annually more than 6 millions live ruminants for slaughter. The majority of these animals are imported from countries where FMD is enzootic. Serotypes of FMD virus not incorporated in the vaccine currently used in Saudi Arabia (e.g. SAT1 and SAT2) are prevalent in some of these exporting countries, and in others, the prevalent serotypes of FMD virus are not routinely typed. However, no isolation of FMD carrier virus could be made from 209 proband samples collected from sheep and goats imported from countries where FMD is enzootic. Particular emphasis has been placed on the possibility of importing either carrier animals which might act as potential source of infection or subclinically infected animals which might actively excrete FMD virus (Hafez, et al. 1994b). Data on the epizootiological status of FMD in all districts of Saudi Arabia were obtained through responses to a specifically-designed questionnaire from field veterinarians working in different Directorates of Agriculture throughout the country. Suspected clinical occurrence of the disease was reported in seventeen of the twenty-three Directorates. The animal species affected were mainly cattle (in fifteen Directorates) and sheep (in eight Directorates). The disease was suspected among goats and camels in only two Directorates. Some animal owners were unwilling to notify suspicion of the disease. Laboratory diagnosis was not performed in all cases. Vaccination using an appropriately-formulated quadrivalent vaccine incorporating FMD virus serotypes O, A, C and Asia 1 was mainly applied to dairy animals. Limited numbers of locally-bred cattle and sheep were vaccinated in eight and four Directorates, respectively (Hafez, et al. 1993b). Specifically-designed questionnaires were distributed to the managers and/or veterinarians of all dairy farms in Saudi Arabia in order to obtain data on the occurrence of foot and mouth disease (FMD) on these farms from 1971 to 1989, as well as data on current control measures. Of 39 farms, 27 responded to the questionnaire and 15 (56%) reported FMD outbreaks. Notification and collection of samples for diagnosis were not performed consistently (Hafez, et al. 1993c).

Concerning the importance of applying local FMD diagnosis in Saudi Arabia, an indirect sandwich enzyme-linked immunosorbent assay (ELISA) was applied. Testing of samples received from 43 outbreaks revealed positive FMD diagnosis in 29 outbreaks (27 caused by serotype "O" and 2 caused by serotype "A" of FMD virus). In addition, ELISA serotyping of 35 carrier strains of FMD virus (isolated from 286 proband samples) revealed 28 serotype "O" and 7 serotype "A" FMD viral isolates (Hafez, et al. 1993a). Also, an immunodiffusion test using FMD virus infection-associated (VIA) antigen was used to detect precipitating antibodies in serum samples collected from non-vaccinated indigenous ruminants raised in different regions of Saudi Arabia. Of 5,985 sheep sera, 1,371 goat sera, 1,052 cattle sera and 694 serum samples from unspecified species of ruminants, precipitating activity was detected in 1,209 (20%), 127 (9%), 172 (16%) and 38 (5%) samples, respectively (Hafez, et al. 1994a).

Foot-and-mouth disease (FMD) is one of the most serious transboundary animal diseases. It is a highly contagious viral disease, and may have rapid and unanticipated national and international spread. Although not a very lethal disease for adult animals, it can cause crippling socio-economic consequences, through high production and trade losses. FMDV serotype O was first isolated in 1990 in India. It quickly spread to Saudi Arabia and neighboring countries as a result of trade in live sheep and goats. By 1996, it had reached Turkey and from there it spread into Greece and Bulgaria. By 1999, outbreaks were reported in Iran, Iraq, Syria, Israel, Lebanon and Jordan. Two years ago it struck three well-managed FMD vaccinated dairy farms in Saudi Arabia (FAO, 2000). Partial nucleotide sequence of the capsid polypeptide coding gene 1D (VP1) was determined for 68 serotype O FMD viruses isolated between 1983 and 1995 from outbreaks occurring in Saudi Arabia. The sequences were compared with previously published sequences: 14 viruses of Middle Eastern origin (isolated between 1987 and 1991); and with four vaccine virus strain sequences, three originating from the Middle East (O1/Turkey/Manisa/69, O1/Sharquia/Egypt/72 and O1/Israel/2/85) and one from Europe (O1/BFS 1860/UK/67). The virus isolates from Saudi Arabia and the Middle East vaccine virus strains formed a related genetic group distinct from the European O1virus. Within this large group 12 distinct genetic sublineages were observed (Samuel, et al. 1997).

FMDV serotype O was the most frequent strain during the last decade in Saudi Arabia. It was periodically recurrent every 2 years since 2004 until 2010 as reported in Table (1).

Table 1

Historical occurrence of FMD serotypes in Saudi Arabia and neighboring countries.

Country	Foot and mouth disease serotypes							References
	O	A	C	Asia 1	SAT 1	SAT 2	SAT 3	
Saudi Arabia	2004	1994	1987	1994	1970	2000	-	*
	2006	2005	-	-	-	-	-	***
	2008	-	-	-	-	-	-	****
	2010	-	-	-	-	-	-	****
Bahrain	2003	1965	-	-	1962	-	-	*
	2006	-	-	-	-	-	-	***
	2008	-	-	-	-	-	-	****
Egypt	2000	1972	-	-	-	1950	-	*
	-	2006	-	-	-	-	-	**
	2007	-	-	-	-	-	-	***
Iran	2004	2004	-	2004	1964	-	-	*
	2005	2005	-	2005	-	-	-	**
	2006	2006	-	-	-	-	-	***
	2006	2003	-	-	-	-	-	***
Iraq	2002	1978	-	1975	1962	-	-	*
	1999	1978	1969	1961	1962	-	-	*
Jordan	2006	2006	-	-	-	-	-	***
	2007	-	-	-	-	-	-	****
Kuwait	2004	1977	-	1981	1970	2001	-	*
	2003	1992	1992	1984	1962	-	-	*
Lebanon	-	2006	-	-	-	-	-	**
	2006	-	-	-	-	-	-	***
Oman	2004	-	-	1982	-	-	-	*
Qatar	2001	-	-	-	-	-	-	*
Syria	2002	2002	1969	1988	1962	-	-	*
	2004	2004	-	2002	1965	-	-	*
Turkey	2007	2005	-	-	-	-	-	***
	2007	2007	-	-	-	-	-	****
United Arab Emirates	2003	1990	-	-	-	-	-	*
	2006	-	-	-	-	-	-	***
Yemen	2008	-	-	-	-	-	-	****
Yemen	2004	1998	-	1980	-	1990	-	*

* FAO (2000)

** Shimshony and Economides (2006)

*** FAO (2007)

**** FAO/OIE (2008)

***** Yousef, et. al. (2012)

2. FMD SAT2 outbreaks in Saudi Arabia

In April 2000, SAT2 virus was isolated from a large dairy farm in Saudi Arabia, on which more than 30 percent of the cattle were severely affected with mortality in calves. It has spread to other dairy farms. SAT2 serotype is not one of the serotypes included in the routine vaccination in Saudi Arabia, and all the dairy cattle were totally susceptible. Genetic analysis of the Saudi isolate has shown it to be related, but not closely, to a strain previously isolated in 1998 in Eritrea. The source of the outbreak in Saudi Arabia remains undetermined at present (FAO, 2000). After elapsing of 10 years on the last recorded cases of FMD caused by the virus of serotype A in Saudi Arabia in 1995, new cases of FMD virus, serotype A were diagnosed in two traditional cattle herds in Al-Hota

province, 150 Km south of Riyadh. Clinical signs of fever, vesicular stomatitis and coronitis, with morbidity rate of approximately 90% were reported. FMDV, serotype (A) isolates were identified by indirect sandwich ELISA. Vaccine matching tests (virus neutralization and ELISA), amplification and sequencing of the VP1 of the isolates revealed that the isolates were antigenically closely related with A Saudi 95, A 4164 and A 22 Iraq 24/64 strains, and genetically identical with isolates of A Iran 2005. Fortunately one of these strains (22 Iraq 24/64) is already incorporated in polyvalent FMD-vaccine formula in Saudi Arabia (Hamada, et al. 2008).

3. Spreading of a new genotype of FMDV type A in Saudi Arabia and neighboring countries

According to the World Reference Laboratory for FMD, a new subtype of FMDV serotype A was detected in Iran in 2005. This subtype was designated A/IRN/2005, and rapidly spread throughout Iran and moved westwards into Saudi Arabia and Turkey where it was initially detected from August 2005 and subsequently caused major disease problems in the spring of 2006. The same subtype reached Jordan in 2007 (Klein, et. al. 2007). Such new genotype was described as responsible for recent FMD outbreaks in the Middle East. Initially identified in samples collected in 2003 from Iran, during 2005 and 2006 this FMDV lineage (proposed to be named A-Iran-05) spread into Saudi Arabia and Jordan and then further west into Turkey reaching European Thrace in January 2007. Most recently A-Iran-05 has been found in Bahrain. Throughout the region, this lineage is now the predominant genotype of FMDV serotype A sampled, and has appeared to have replaced the A-Iran-96 and A-Iran-99 strains which were previously encountered. In August 2007, a new A-Iran-05 sub-lineage (which we have called A-Iran-05(ARD-07) was identified in Ardahan, Turkey, close to the border with Georgia. This new sub-lineage appeared to predominate in Turkey in 2008, but has, so far, not been identified in any other country. Vaccine matching tests revealed that the A-Iran-05 viruses are antigenically different to A-Iran-96 and more like A(22). These findings emphasize the importance of undertaking continued surveillance in the Middle East and Central Asia in order to detect and monitor the emergence and spread of new FMDV strains (Knowles, et al. 2009).

4. Recent occurrence of suspected FMD cases during Hajj season

Saudi Arabia imports annually thousands of live animals such as camel, cattle, sheep and goats before Hajj season as requirements of sacrificial meat. Most of imported animals come from Africa countries especially Somalia. As well as, almost of imported cattle and sheep come from Berbera region in Somalia.

On the other hand, periodic outbreaks of FMD virus types O, A and SAT2 were recorded in different geographical locations in Somalia, where no vaccinations against FMD since 1991. The last outbreaks of FMD were observed during years 1998, 2004, 2005, 2006 and 2007. However, serological tests showed exposure of the target unvaccinated cattle herds to FMD virus serotypes O, A, SAT1 and SAT 2. So, effective control of FMD in Somalia will requires imposition of animal movement restrictions and use of multivalent vaccines. Since July 2006, all cattle exported from Berbera vaccinated against sero-types O and A due to requirements by Yemen and UAE (Jabra, 2010).

Many of Berbera cattle, sheep and goats arrived Makkah slaughter houses during Hajj season every year, which may be FMD carriers and make high risk for recurrent occurrence of FMD in Saudi Arabia. Therefore, during Hajj season 1432 H (2011), among 1800 inspected cows during ante mortem examination at Moiseum slaughter house 14 (0.78 %) showed classical symptoms and lesions of FMD. Suspected cases were suffered from salivation (fig. 1), in addition to blisters and ulcers on gums and lips as well as on feet (Fig. 2 and 3). Such findings indicated the possibility of recurrent appearance of FMDV in Saudi Arabia through imported carrier animals which might act as potential source of infection or subclinically infected animals which might actively excrete FMD virus.

The virus is spread by inhalation or ingestion. Initial outbreaks are most commonly caused by ingestion (e.g. infected meat), but rapid spread within a herd is likely via inhalation (airborne virus). Wind and humidity appear to increase windborne spread. Virus spread has been estimated, under the right conditions, to be as far as 62 miles. Up to 50% of infected animals may remain as carriers of the disease for at least 6 months. Virus has been recovered from nasal secretion of people for up to 28 hours after working with infected cattle and can survive in the environment for 10 – 12 weeks on clothing and feed, and 30 days on hair (FAO, 2000). Outbreaks of FMD repeatedly occur among cattle, sheep and goats in various regions of Saudi Arabia (Hafez et.al. 1993b). The Camelidae are susceptible species to FMD, similar to cattle, sheep and goats but infection dynamics vary across these species (OIE, 2009). Camels are frequently moved across the desert inside Saudi Arabia in an area that

experienced FMD outbreaks in cattle and small ruminants so camels may play a possible role in the transmission of FMDV and may carry FMDV over very long distances and across borders (Yousef, et al. 2012).



Fig. 1. Ruptured mouth vesicles cause excess salivation.



Fig. 2. Mouth blisters and ulcers of suspected FMD lesions.



Fig. 3. Suspected FMD lesions on feet.

5. Prevention and control strategies

Prevention strategies should describe the measures to be taken in order to minimize the risk of introduction and establishment of exotic FMD virus strains into Saudi Arabia, taking into account the assessed risks of introduction and the available strategies for reducing these risks through the control of transboundary livestock movements and management of importation of both animal products and waste materials of animal origin.

Understanding the epidemiology of FMD is essential for the formulation of the most effective control strategies. Also, determining the source of outbreaks is an important element of epidemiological investigations (Samuel and Knowles 2001).

The most important resource in the prevention of FMD is the informed animal owner or manager. Livestock owners at all levels of production, dealers and traders should be familiarized with the basic features of FMD, including recognizing the essential signs of the disease, the need for urgent action and how and where to seek help if they suspect the disease. This can only be achieved by intensive farmer training, using media that are easily understood, highly visual, and that serve as a constant reminder of the disease and its importance. Lines of communication must be established between livestock owners and the veterinary services, using local authorities and agricultural personnel as intermediaries when necessary, who should also be informed about FMD. Furthermore, FMD prevention and control should be done through import controls and quarantine, including control of animals in transit, good hygiene and sanitary practices, removing potentially contaminated materials from the environment by cleaning, disinfection and/or safe destruction, preventing the feeding of contaminated materials to livestock and avoiding contact between infected and susceptible animals.

Although vaccination may reduce the clinical symptoms of FMD, it does not eliminate infection or prevent the carrier state because infection or vaccination against one serotype does not provide protection against the other serotypes (FAO, 2007). Vaccinated animals must be eventually slaughtered if the virus is to be completely eradicated.

In order to improve national control of FMD in Saudi Arabia, the Government represented by Ministry of Agriculture has decided to initiate long-term investigations in collaboration with International Organization as WHO, FAO and OIE. Prior to commencement of these investigations, it was necessary to increase understanding of the epizootiology of FMD in Saudi Arabia.

Foot-and-mouth disease (FMD) is the most contagious transboundary animal disease (TAD) affecting cloven hoofed animals. Significant economic losses are produced by its high morbidity and the export trade restrictions imposed on affected countries.

6. Conclusion

There is an evident for the possibility of recurrent occurrence of FMDV in Saudi Arabia through the imported ruminants from countries where FMD is enzootic, particularly during Hajj season. Such imported animals may be FMDV carriers or subclinical cases or showing suspected FMD lesions as recorded during last Hajj season (2011). So, risk analyses for FMD should provide an estimate of the degree of risk of the disease introduction, the most likely mechanisms and portals of FMD entry and the potential seriousness of the consequences if the disease enters Saudi Arabia. This should provide the basis for designing and implementing appropriately resourced preventive strategies for FMD.

Import control, including quarantine, is considered the first line of defense against recurrent appearance of FMDV in Saudi Arabia. All countries should devote an appropriate level of resources to ensuring that they implement effective border and import quarantine policies and programs to prevent introduction of FMDV.

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