Foot-and-Mouth Disease

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Foot-and-mouth Disease

Disease Basics
Foot-and-mouth Disease

Contents

- Definition and Etiology
- Host range
- Incubation
- Clinical signs
- Transmission
- Diagnosis
- Differential Diagnosis
Foot-and-mouth Disease

Known around the world as

- Afta epizotica
- Bek-en-klouseer
- Fiebre Aftosa
- Fievre aphteuse
- Maul-und-Klauenseuche
Foot-and-Mouth Disease

Foot-and-mouth disease is a highly contagious, viral disease of domestic cloven-hoofed and many wild animals characterized by erosions in the mucosa of the mouth and hooves.

Image courtesy of Dr Tom McKenna
This devastating disease is considered to be the most important livestock disease in the world.

It is *THE* most contagious virus disease of animals.

It has not occurred in the US since 1929.
Worldwide Occurrence of FMD

Foot-and-Mouth Disease
Countries that are foot-and-mouth disease-free do *NOT* want to re-import the disease.

FMD free countries have instituted embargoes on agricultural imports from countries where effective control is not practiced.
Important factors

- Short incubation period
- Release of virus prior to appearance of clinical signs
- Massive quantities of virus released
Extended survival in the environment
Multitude of routes of virus transmission
Minimal size of the infective dose

Aerosol transmission possible up to 250 km depending on strain and environmental conditions (10km, 170km, 250km reported over water)
Foot-and-Mouth Disease

- Although not very lethal to adult animals, it causes serious production losses.

- FMD is a major constraint to international trade in livestock and livestock products.
Foot-and-mouth Disease:

- Etiology
- Host range
- Incubation
- Clinical signs
- Transmission
- Diagnosis
- Differential Diagnosis
Etiology

The virion is non-enveloped, small, (about 23-25 nm in Diameter), and has icosahedral symmetry. It is composed of a single-stranded RNA genome of about 8,000 nucleotides.
Etiology
Foot-and-mouth Disease virus (FMDV)

- Family Picornaviridae, genus *Aphthovirus*
- 7 serological types:
  - Type A
  - Type O,
  - Type C,
  - South African Territories (SAT) 1,
  - South African Territories (SAT) 2,
  - South African Territories (SAT) 3,
  - and Asia 1
Etiology
Foot-and-mouth Disease virus (FMDV)

- Over 60 subtypes
- Antigenic variation seems to be greatest for Serotype A.
Foot-and-mouth Disease:

- Etiology
- Host range
- Incubation
- Clinical signs
- Transmission
- Diagnosis
- Differential Diagnosis
Host Range

All cloven-hoofed domestic animals:

Cattle and Buffalo
Sheep
Goats
Swine

Foot-and-Mouth Disease
Host Range

Most cloven-footed *wild animals*:

- Deer
- Bison
- Feral hogs
- Antelope

Foot-and-Mouth Disease
Host Range

Water buffalo

can be carriers for 5 years

Llamas and alpacas

are susceptible, but of no epidemiological significance

African water buffalo

Foot-and-Mouth Disease
Host Range

Giraffes

Elephants

Foot-and-Mouth Disease
Host Range

Armadillos
Armadillos are not only susceptible but are capable of transmitting the disease to each other and possibly to other species

USAHA Proceedings 1974:
“Clinical and serological response of the Nine-banded armadillo (Dasypus novemcinctus) to viruses of African Swine Fever, Hog Cholera, Rinderpest Vesicular Exanthema of Swine, Vesicular Stomatitis and Foot-and-mouth disease”

Foot-and-Mouth Disease
Host Range

Hedgehogs
Nutria
Capybaras

Rats, Mice and Guinea pigs can be infected experimentally

Foot-and-Mouth Disease
http://www.hedweb.com/animimag/capybara.htm
Host Range

Not seen in odd-toed animals such as horses, zebras or rhinos.
Old World Camel is resistant to natural infection

Foot-and-Mouth Disease
Host Range

Foot-and-Mouth Disease
Foot-and-mouth Disease:

- Etiology
- Host range
- Incubation
- Clinical signs
- Transmission
- Diagnosis
- Differential Diagnosis
Incubation

Incubation period depends on which strain of FMD virus (7 serotypes), dosage, and the route of entry.

As short as 2-3 days in close contact
As long as 10-14 days from windborne infection
Experimentally shown to be as short as 18-24 hours
Minimum doses of FMD virus to initiate infection

<table>
<thead>
<tr>
<th>Animal</th>
<th>Respiratory Route</th>
<th>Oral Route</th>
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<tbody>
<tr>
<td>Cattle</td>
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<td>1X 10&lt;sup&gt;6&lt;/sup&gt; TCID&lt;sub&gt;50&lt;/sub&gt;</td>
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<tr>
<td>Pigs</td>
<td>20 TCID&lt;sub&gt;50&lt;/sub&gt;</td>
<td>8X 10&lt;sup&gt;3&lt;/sup&gt; TCID&lt;sub&gt;50&lt;/sub&gt;</td>
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<tr>
<td>Impalas</td>
<td>1 TCID&lt;sub&gt;50&lt;/sub&gt;</td>
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</tbody>
</table>

Foot-and-Mouth Disease
Pathogenesis

- Most animals acquire virus usually by inhalation
- Humans and pigs are more susceptible to infection by oral route
Pathogenesis

- Initial replication in terminal bronchioles, 24hpi
- Subsequent viremia with spread to stratified squamous epithelium
Cytolytic replication in stratum spinosum cells, creating vesicle

Foot-and-Mouth Disease
Foot-and-mouth blisters on a pig's snout

Foot-and-Mouth Disease
24 hrs after infection, virus begins replicating

Virus is excreted in high quantities in expired air, in all secretions including milk, and from ruptured vesicles.

Pigs can excrete up to 400 million infective virus particles a day
Excretion of FMD virus can begin up to 14 days BEFORE clinical disease becomes apparent.
Pathogenesis

- Virus replication in respiratory epithelium and lymphoid tissue

- In domestic ruminants pharynx and dorsal soft palate are predilection site for replication of FMDv

- Virus persists there for prolonged periods
Replication in lymphoid tissue, tonsils
mucosa of soft palate

Virus can be recovered from
retropharyngeal, mandibular, and parotid
lymph nodes in more than 50% of cattle in
pre-viremic stage

Foot-and-Mouth Disease
High virus levels may occur in organs and tissues which do not generally develop gross changes including unaffected skin areas.
Characteristic Blister Formation

- Epithelial lesions of FMD are initiated by infection of single cells in the stratum spinosum.
- Following infection, bullae develop by lysis of cell swollen by degeneration and release of intracellular fluid or focal intercellular edema
- Bullae coalesce and rupture

Foot-and-Mouth Disease
Characteristic Blister Formation

Development of characteristic vesicular lesions depends on 2 factors:

– Infection of epithelium
– Persistent local irritation or friction
This explains why the mouth, feet and teats are predilections sites for blisters in cattle;

- the dorsum of the snout in pigs from snuffling,

- on the knees of warthogs that kneel when feeding
Foot-and-mouth Disease:

- Etiology
- Host range
- Incubation
- Clinical signs
- Transmission
- Diagnosis
- Differential Diagnosis
General Clinical Signs

Foot-and-Mouth Disease
General Clinical Signs

- Vesicles and erosions in the mucosa of the mouth, and skin-hoof junction
- Excessive salivation
- Lameness
General Clinical Signs

- Listless
- Lifting feet alternately
- Lameness
- Clear nasal discharge progressing to mucopurulent

Foot-and-Mouth Disease
Blisters in the mouth
Blisters on the muzzle
Blisters on the tongue
Excessive Salivation

Foot-and-Mouth Disease
Foot-and-Mouth Disease
• Signs develop rapidly in cattle and are more severe than lesions in pigs, sheep or goats.

• If all species are exposed together, cattle will show signs first.

• Some serotypes of FMDV affect particular species more than others.
Clinical Signs in Cattle

- Fever (103°-106°F)
- Depression
- Anorexia
- Milk production ceases
- Blisters start to form in the mouth
- Excessive ropy, viscous salivation
- Blisters rupture within 24 hrs leaving raw, painful ulcers
- Mouth lesions usually heal in 10 - 14 days

Foot-and-Mouth Disease
Clinical Signs in Cattle

Blisters form on:

**Mouth**
- Tongue
- Dental pad
- Gums
- Soft palate

**Feet**
- Inter-digital space
- Coronary band

**Teats**

**Muzzle**

**Nostrils**
Foot-and-Mouth Disease
Foot-and-Mouth Disease
Foot-and-Mouth Disease
Foot-and-Mouth Disease
Clinical Signs in Cattle

- Body tremors from pain
- Lameness from developing lesions on feet

Foot-and-Mouth Disease
Clinical Signs in Cattle

- **Lameness**
  - Coronary band lesion first appears blanched
  - Blisters form between the digits
  - Stamping and shaking of feet
  - Trembling

Foot-and-Mouth Disease
Clinical Signs in Cattle

- Smacking of the lips and sucking of the sore tongue is characteristic
- Secondary Bacterial infections
- Mastitis – permanent damage to udder
- Pregnant cows may abort

Foot-and-Mouth Disease
Progression of disease

- Blisters at infection site initially appear as blanched area in the epithelium
- Area fills with serous fluid forming a vesicle
- Vesicles enlarge and coalesce
- Vesicles crack or rupture leaking fluid
- The epithelium necroses off leaving raw ulcer or erosion
Progression of disease

- Grey fibrinous coating forms over lesions
- The coating becomes discolored, yellow, brown, green
- As epithelium is restored, lines of demarcation are evident
- Sometimes but not always, permanent scars form

Foot-and-Mouth Disease
Progression of disease

- When blisters are present, cattle salivate profusely with ropy viscous material hanging from mouth
- Also see severe lacrimation and nasal discharge
- When vesicles rupture, fever ends followed by end of viremia
- Start to finish, signs last 15-30 days.
Progression of disease

- Recovered animals are permanently unthrifty
Aging lesions in cattle

Day One

Formation of fluid-filled blister, or vesicle
2 mm-10 cm on the dorsal surface of the tongue

Foot-and-Mouth Disease
Aging lesions in cattle

Salivation increases as vesicles form and rupture. Symptoms increase in intensity.

Foot-and-Mouth Disease
Aging lesions in cattle

Days 8-14

Animals may recover in 2 weeks. Only 1-5% die from FMD

*High morbidity, Low mortality*

Lines of demarcation

Foot-and-Mouth Disease
Clinical Signs in Cattle

- Morbidity approaches 100% in a susceptible herd.

Foot-and-Mouth Disease

FMD – Brazil, Argentina, Uruguay. 2000
Clinical Signs in Cattle

- Low Mortality
  - Rarely fatal except in young animals

- Extra-epithelial replication limited to myocardium, immature animals only
Clinical Signs in Cattle

Young calves may die without showing any clinical signs.

Foot-and-Mouth Disease
In young animals there is focal necrosis of cardiac muscle. “Tiger heart”

50-80% young animals die (calves, lambs, etc)
Recovery

- Recovered animals are “poor doers”

Foot-and-Mouth Disease
Recovery

“More than 200 cows infected in Cambodian foot-and-mouth disease outbreak”

A cow stands on a bank of the Tonle Sap River. More than 200 cattle in Cambodia have been infected with foot-and-mouth disease since an outbreak last month northwest of the capital, but have since recovered.

http://www.todayonline.com/articles/63247.asp

Foot-and-Mouth Disease
Up to 50% of recovered ruminants continue to shed the virus sporadically, 6-24 months post-infection.
Water buffalo can be carriers for 5 years

Foot-and-Mouth Disease
Clinical Signs in Swine

- Fever
- No appetite

- Reluctant to move
- Worst blistering is on the feet
- May slough the hoof

- Abortion
- Suckling piglets die suddenly – even before blisters develop

Foot-and-Mouth Disease
Foot-and-Mouth Disease
Foot-and-Mouth Disease
Clinical Signs in Swine

Blisters on teats and udders

Mastitis

Foot-and-Mouth Disease
Clinical Signs in Swine

Pigs – Reluctance to move, painful toes

Foot-and-Mouth Disease
Foot-and-Mouth Disease
Clinical Signs in Sheep and Goats

- Vesicles on dental pad and between toes
- Prone to develop secondary foot-rot
- Lamb death, 50-90%
- Sheep can be carriers for up to 9 months

Foot-and-Mouth Disease
Foot-and-Mouth Disease
Foot-and-Mouth Disease
Clinical Signs in Sheep and Goats

When sheep or goats become infected with FMD, the disease may not be diagnosed for a considerable time because the clinical signs may be very mild.
Sheep may appear healthy but will be producing infectious aerosols or spreading the virus via urine, feces or direct contact.
Lesions in giraffe

Foot-and-Mouth Disease
Foot-and-mouth Disease:

- Etiology
- Host range
- Incubation
- Clinical signs
- Transmission
- Diagnosis
- Differential Diagnosis
Transmission

- Aerosols/Airborne, Inhaled
- Direct or indirect contact-droplets,
- Ingestion
- Artificial Insemination
- Vectors (vehicles, equipment, or humans)
- Carrier state
Transmission

Aerosol

- Spread of aerosols from infected animals, given the right temperature and humidity can travel 250km on the wind

- Aerosols transmission via dust storms in Africa spread FMD to England
Transmission

- Airborne on the wind
- Airborne from burning pyres suspected
- Airborne from infected milk transport

Foot-and-Mouth Disease
Transmission

Aerosol droplets spread from infected animal

Sheds 400,000,000 virus particles per day

Only takes 10-12 virus particles to infect one cow
Transmission

Direct or indirect contact with infected animals

If infected feral hogs come into contact with domestic livestock in the US, it will affect the whole world!

Foot-and-Mouth Disease
Transmission

Foot and mouth disease virus can be transmitted via:

- Milk
- Semen
- Saliva
- Feces
- Urine
- Breath

“Supersoaker fights on the dairy farm”
Transmission

- Ingestion- Feeding contaminated garbage (meat, milk, glands, bones, cheese, etc)

- Intraocular

- Artificial insemination, or natural reproduction

Foot-and-Mouth Disease
Vectors

Contact with contaminated objects (equipment, footwear, clothing)
Transmission by humans

A person in contact with infected animals may retain and exhale virus for up to 36 hours and serve as source of infection.

Humans serve as a mechanical vector when moving from infected animals to susceptible animals.
Transmission

Birds can be mechanical vectors and can pass viable FMD virus after ingestion, but are not considered a factor in the spread of the disease.
Birds can also be infected with FMD virus and shed virus in feces.
Intentional act of Bioterrorism

Effective if humidity is >60%

Can travel 60km overland or 300km over water

www.skysailing.com/images/nzcropduster.jpg

Foot-and-Mouth Disease
Foot-and-mouth Disease:

- Etiology
- Host range
- Incubation
- Clinical signs
- Transmission
- Diagnosis
- Differential Diagnosis
Diagnosis

- Serum neutralization test
- Complement fixation test
- Enzyme-linked immunosorbent assay

Field diagnosis

Foot-and-Mouth Disease
Foot-and-Mouth Disease

FMD Testing

Tissues Vesic. Fluid Probang Swab

- Virus isolation ≥ 7 days
- RT-PCR 6 hr
- Realtime PCR 2 hr

Virus ID

Electron Microscopy

Tissues VF

- Ag-ELISA 5 hr
- CF-Ag 3hr
## Laboratory Diagnosis

<table>
<thead>
<tr>
<th>For virus</th>
<th>For antibodies</th>
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<tr>
<td>ELISA</td>
<td>Virus neutralization</td>
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<tr>
<td>Virus isolation</td>
<td>Agar gel immunodiffusion</td>
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<tr>
<td>PCR*</td>
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Foot-and-Mouth Disease
Foot-and-mouth Disease:

- Etiology
- Host range
- Incubation
- Clinical signs
- Transmission
- Diagnosis
- Differential Diagnosis
Differential Diagnosis

As a vesicular type disease:
- Vesicular stomatitis,
- swine vesicular disease of pigs,
- vesicular exanthema of pigs
Differential Diagnosis

Based on ulcerative lesions in the mouth or on the muzzle:

- BVD/MD
- MCF
- Bluetongue and other orbiviruses
- LSD
- IBR
- Rinderpest
Differential Diagnosis

Based on foot lesions:

- Dermatophilosis
- Foot-rot
- MCF
Differential Diagnosis

- Vesicular Stomatitis
- Bovine Mammilitis
- Bovine Viral Diarrhea
- Bovine Papular Stomatitis
- Mucosal Disease (foot lesions)
- Infectious Bovine Rhinotracheitis
- Rinderpest
- Bluetongue (foot lesions)
- Peste des Petits Ruminants
- Foot Rot
- Chemical Irritants
- Swine Vesicular Disease
- Vesicular Exanthema - swine
FMD or VS?

Cannot distinguish clinically

Foot-and-Mouth Disease
FMD vs VS

- VS is not as contagious as FMD
- FMD does not affect horses
- VS - Domestic animals are probably not primary hosts.
- VS - Vector-borne disease.
- VS - No effective vaccines available in US.
- VS - Requires specific ecological conditions.
- VS - Infects large number of wild species.
- Both are zoonotic diseases

Foot-and-Mouth Disease
Rapid spread of foot-and-mouth disease world-wide....
FMD Type O 2001
Foot-and-Mouth Disease
Distribution and Recent Activity

(Rev. 5-05-01)
Images Acknowledgement

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Bibliography


O.I.E.


Personal interviews with Dr Logan, Dr McKenna, Dr Coetzer, Dr VanVuuren and Dr Waldrup

Foot-and-Mouth Disease
Foot-and-mouth Disease

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