Measles (Rubeola) Virus

*Paramyxoviridae*
Genus *Morbillivirus*

Enveloped single-stranded RNA virus

Reservoir Host: Human

Related Viruses
- Canine distemper
- Rinderpest
- Peste des petits ruminants
- Phocine distemper
- Dolphin distemper
- Porpoise distemper

Phylogeny of Known Morbilliviruses
Measles Virus Genetic Variants

Measles Virus Genetic Groups

Figure 3. Global distribution of measles genetic groups. Colored circles indicate areas where measles viruses from various genetic groups have been isolated. Viruses not assigned to one of the eight groups are labeled in brown.
Measles Epidemiology

Resurgence Associated with Group 2 Virus
Human Measles Cases
Vaccination Status

Measles (Rubeola) Virus Infection

**Transmission:** Aerosol droplet; direct contact with nasal or throat secretions, fomites

*Highly* infectious virus

**Disease:** Similar in humans and nonhuman primates

Most species of primates are susceptible

Incubation period 7-14 days

Infectious period 1-2 days prior to onset of prodrome to ~ 4 days after appearance of rash

Subclinical infections have been documented
Measles Virus Infection

Clinical Measles

*Prodrome:* 7-14 days after infection
- Lasts 2-3 days
- Fever, malaise, anorexia, coryza, cough, conjunctivitis, Koplik spots

*Rash:* 3-7 days post onset
- Maculopapular eruption
- Starts on head/face – spread to trunk/limbs becoming generalized
- Persists 3-4 days

*Leukopenia* - common
Measles Virus Pathogenesis

Complications
- Primary viral or secondary bacterial
  - Otitis media
  - Pneumonia
  - Encephalitis
  - Enteritis

Sequelae
- Subacute Sclerosing Panencephalomyelitis (SSPE)
  (Reactivation of latent MV?)
Primary measles interstitial pneumonia and hemorrhage

Coalescing rash and inguinal lymphadenopathy

“Morbilliform” maculopapular rash in human and rhesus macaque

Measles Virus Infection
Measles Virus Infection
Atypical Koplik’s Spots in NHP

Koplik’s spots – pale areas of focal necrosis usually found in buccal mucosal epithelium

Measles Virus Infection
Pathologic Features

- Broad Tissue Tropism
- Intranuclear inclusions
- Formation of multinucleated “giant cells” (Syncytia)
Measles Virus Immune Suppression

Impaired cellular immune function

Impaired humoral immune function

CNPRC Measles Outbreak, 1987
Human Measles Cases
CNPRC Measles Outbreak 1987

<table>
<thead>
<tr>
<th>Case #</th>
<th>Sex</th>
<th>Age</th>
<th>Onset</th>
<th>Exposure</th>
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<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>28</td>
<td>1-28-87</td>
<td>Employee; animal contact</td>
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<tr>
<td>2</td>
<td>M</td>
<td>30</td>
<td>2-8-87</td>
<td>Household contact case 1</td>
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<td>3</td>
<td>F</td>
<td>27</td>
<td>2-25-87</td>
<td>Employee; animal contact</td>
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<tr>
<td>4</td>
<td>F</td>
<td>21</td>
<td>3-7-87</td>
<td>Employee; animal contact</td>
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<tr>
<td>5</td>
<td>F</td>
<td>22</td>
<td>3-22-87</td>
<td>Employee; animal contact</td>
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</tbody>
</table>

CNPRC Measles Outbreak 1987
Epidemiologic Evidence of Monkey-to-Human Transmission

Case 3
Exposed to confirmed monkey measles on 2/16/87
Onset of measles on 2/25/87 (9 days)
No known exposure to human cases (CNPRC or community). Worked only weekends

Case 4
Exposed to confirmed monkey measles on 2/24/87
Onset of measles on 3/7/87 (11 days)
No known exposure to human case 3 or other human cases
### Measles Virus Infection
**Abortions/Stillbirths Outdoor-housed Macaques**
CNPRC 1984-1987

<table>
<thead>
<tr>
<th>Birth Year</th>
<th>Pregnancies</th>
<th>Stillbirths/Abortions</th>
<th>%</th>
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<tbody>
<tr>
<td>1984-85</td>
<td>169</td>
<td>30</td>
<td>21.6</td>
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<td>1985-86</td>
<td>171</td>
<td>31</td>
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<tr>
<td>1986-87*</td>
<td>120</td>
<td>55</td>
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* Measles outbreak

### Measles Virus Infection
**Neonatal* Mortality in Macaques**
CNPRC 1984-1987

<table>
<thead>
<tr>
<th>Birth Season**</th>
<th>Housing</th>
<th>Live Births</th>
<th>Neonatal Deaths</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>1984-85</td>
<td>Indoor</td>
<td>34</td>
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<tr>
<td></td>
<td>Outdoor</td>
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<td>5.0</td>
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<tr>
<td>1985-86</td>
<td>Indoor</td>
<td>43</td>
<td>1</td>
<td>2.3</td>
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<tr>
<td></td>
<td>Outdoor</td>
<td>140</td>
<td>8</td>
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<tr>
<td>1986-87*</td>
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<td>85</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Outdoor</td>
<td>65</td>
<td>23</td>
<td>35.4</td>
</tr>
</tbody>
</table>

* Neonate = < 28 days of age
** Through April of each year
* Measles outbreak
Measles Virus Infection
Wild Nonhuman Primates

Measles virus antibodies found in wild NHP populations having human contact (low prevalence)

Possible introduction of measles into habituated troop of Mountain Gorillas 1988, 1990

Measles Virus Infection
Treatment and Prevention

No specific treatment
Supportive care
Prevention of secondary bacterial infections

Natural infection confers life-long immunity

Vaccine preventable disease
Attenuated live MV vaccine (Attenuvax)
Canine distemper-measles vaccine provides protection against MV challenge in NHP*
Attenuated live MV vaccine may be pathogenic in New World monkeys
