Rabies!!!

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@bloodman
DISCLOSURE

Relevant Financial Relationship(s)
None
Case Study 1

- Faculty member enjoying a tropical vacation
- Masseuse notices small wounds near ankles
Cast Study 2

- You get a call from one of your co-workers
- While riding a bike, a dog runs across field, lunges at him and bite his legs and runs off....
Rabies: History

• Known for thousands of years
• Babylon legal code 2300BC – paid fine if your dog gave someone rabies
• Recognized by Aristotle
• “Rabere” Latin “to be mad”
• Pasteur created vaccine
• 1940-50 – dog rabies eliminated US
Rabies: Epidemiology

- Still terrible problem world-wide
- ~ 60,000/deaths
- Mainly via dogs
- 95% Africa/Asia
Deaths per capita  WHO
Presence of dog-transmitted human rabies
- Absent
- Suspected
- Confirmed
- Unknown
Rabies: USA

- Last century 30-50 case/yr
- Currently ~ 2 deaths/yr
- Dog rabies almost eliminated
- Most cases bats or “imported”
Rabies: Travelers

- 30 years review
- 52% Asia
- 50% Visiting home
- 75% Male
- 81% Dogs

- Travel med ID 2020
The Virus

- Lyssavirus
  - Lyssa: the goddess of rage
- Member of Rhabdoviridae family
- Negative stranded RNA virus
- Very labile!
  - Inactivated by sunlight, heat, desiccation
The Virus

• Bullet shaped 200 nm x 80
• 5 proteins
  – Nucleoprotein
  – Phosphoprotein
  – Matrix protein
  – Glycoprotein
  – (L)Polymerase
How do we get Rabies?

- Bites
- Inhalation
- Scratched/licking
- Transplantation
Bites

- Rate of infection 5-80%
- Most common mode of transmission
- Deep crushing wounds highest rates
  - Rabies “injected” into muscle
Scratches

• Bats
  – Lick claws
  – Licks opened wounds
  – Scratches skin
  – ~ 0.1-1%
Inhalation

• One documented laboratory case
• Controversial spelunker cases
  – Unnoticed bat bites?
Transplant

- Rare reports of organs spreading rabies
- Corneas most common
- Solid organs twice in USA
  - 2004, 2013
Pathophysiology: Overview

- Virus replicates in muscle cells
- Ascends peripheral nerves
- CNS: Massive replication
- Transmitted via efferent nerves
- Viral replication salivary glands
Post-Bite

- Virus replicates in muscle
  - Can take time
- Uptake by motor endplates
- Higher risk of infection in deep muscle wounds
Neuron Uptake

- Via virus G protein
  - Acetylcholine receptor
  - NCAM (CD56)
  - TNFRSF16
Axonal Travel

- Virus buds from muscle cells into the clefts of the NMJ
- Retrograde axonal transport
- Mainly motor neurons
- ~ One synapse every 12 hours
- 50-100 mm/day
CNS

• When virus reaches CNS massive replication
• Spreads “centrifugally” through all nerves
• Leads to behavioral changes
  – Key to “spreading” virus
• Salivary glands high innervated
  – Virus shed in saliva
Axial Fluid-Attenuated Inversion Recovery MRI Scan Showing Profound Signal Abnormalities within the Bilateral Frontal and Temporal Lobes, Hippocampi, Basal Ganglia, and Medulla in Patient 2.
Lack of Immune Response

- In CNS rabies evades immune response
- Does not stimulate interferon or other antiviral response
- Can see antibody production in clinical infection
Pathology

- Only mild changes seen in the CNS!
  - Negri bodys: Viral replication (50%)
- No inflammatory response
- "Need" intact nervous system to spread virus
1. Virus inoculated

2. Viral replication in muscle

3. Virus binds to nicotinic acetylcholine receptors at neuromuscular junction

4. Virus travels within axons in peripheral nerves via retrograde fast axonal transport

5. Replication in motor neurons of the spinal cord and local dorsal root ganglia and rapid ascent to brain

6. Infection of brain neurons with neuronal dysfunction

7. Centrifugal spread along nerves to salivary glands, skin, cornea, and other organs


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What Animals Get Rabies?
Global distribution of mammalian rabies reservoirs and vectors

Rupprecht CE. The Lancet Infectious Diseases. 2002
USA

- More rabid cats than dogs in USA
- Dogs biggest threat world-wide
  - Also foxes, mongooses, raccoons, jackals, and wolves
European Vectors

- Dog rabies also eliminated
- Red fox biggest reservoir
- Bats not rabid
  - Have rabies like viruses
USA Animals

The diagram shows the number of rabid animals reported in the USA from 1967 to 2017, categorized by different animal species:
- Raccoons with raccoon variant
- Skunks (Total)
- Skunks with skunk variant
- Foxes
- Bats
- Trendline

The number of rabid animals varies over the years, with peaks in certain years and a general declining trend from 1995 onwards.
Dogs and Cats

Number of Rabies Cases Among Dogs and Cats, United States—2008–2009

- 2008: 75 Dogs, 81 Cats
- 2009: 294 Dogs, 300 Cats

2018:
- Dogs: 63
- Cats: 241

2019:
- Dogs: 66
- Cats: 245
Other Animals

- Carnivores – 2-20%
- Rodents/rabbits – very rare
  - Exception groundhog
Table 2—Number of animals reported to be rabid in the United States, including Puerto Rico, and percentages of samples tested for rabies that yielded positive results for 2014 through 2019.

<table>
<thead>
<tr>
<th>Animals</th>
<th>No. of rabid animals</th>
<th>No. of animals tested with positive or negative result</th>
<th>Percentage of samples with positive result</th>
<th>No. of rabid animals</th>
<th>Percentage of samples with positive result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic animals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cats</td>
<td>245</td>
<td>21,169</td>
<td>1.2</td>
<td>258</td>
<td>238–278</td>
</tr>
<tr>
<td>Cattle</td>
<td>39</td>
<td>985</td>
<td>4.0</td>
<td>60</td>
<td>30–91</td>
</tr>
<tr>
<td>Dogs</td>
<td>66</td>
<td>22,472</td>
<td>0.3</td>
<td>62</td>
<td>57–66</td>
</tr>
<tr>
<td>Horses and donkeys</td>
<td>22</td>
<td>777</td>
<td>2.8</td>
<td>18</td>
<td>10–25</td>
</tr>
<tr>
<td>Sheep and goats</td>
<td>10</td>
<td>624</td>
<td>1.6</td>
<td>10</td>
<td>8–13</td>
</tr>
<tr>
<td>Wildlife</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bats</td>
<td>1,387*</td>
<td>25,327</td>
<td>5.5*</td>
<td>1,635</td>
<td>1,482–1,787</td>
</tr>
<tr>
<td>Raccoons</td>
<td>1,545</td>
<td>13,171</td>
<td>11.7</td>
<td>1,524</td>
<td>1,264–1,783</td>
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<tr>
<td>Skunks</td>
<td>915</td>
<td>3,796</td>
<td>24.1</td>
<td>1,185</td>
<td>839–1,532</td>
</tr>
<tr>
<td>Foxes</td>
<td>361*</td>
<td>1,854</td>
<td>19.5</td>
<td>324</td>
<td>300–348</td>
</tr>
<tr>
<td>All domestic animals</td>
<td>385</td>
<td>46,230</td>
<td>0.8</td>
<td>410</td>
<td>371–449</td>
</tr>
<tr>
<td>All wildlife</td>
<td>4,305</td>
<td>48,540</td>
<td>8.9</td>
<td>4,761</td>
<td>4,028–5,494</td>
</tr>
<tr>
<td>All animals</td>
<td>4,690</td>
<td>94,770</td>
<td>4.9</td>
<td>5,171</td>
<td>4,414–5,928</td>
</tr>
</tbody>
</table>

*Significantly different from mean value for 2014 through 2018.
Bats!
Human Cases

![Bar chart showing the number of human rabies cases by year and source.]

- Dog, foreign (n = 36)
- Other (n = 15)
- Raccoon (n = 4)
- Dog, autochthonous (n = 8)
- Bat (n = 62)

Years:
- 1960-1965
- 1966-1970
- 1971-1975
- 1976-1980
- 1981-1985
- 1986-1990
- 1991-1995
- 1996-2000
- 2001-2005
- 2006-2010
- 2011-2015
- 2016-2018

No. of human rabies cases
<table>
<thead>
<tr>
<th>Date of onset</th>
<th>Date of death</th>
<th>Reporting state</th>
<th>Age (y)</th>
<th>Sex</th>
<th>Exposure*</th>
<th>Rabies virus variant†</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-Oct-18</td>
<td>4-Nov-18</td>
<td>UT</td>
<td>55</td>
<td>M</td>
<td>Contact</td>
<td>Bat, Tb</td>
</tr>
<tr>
<td>15-Jul-18</td>
<td>23-Aug-18</td>
<td>DE</td>
<td>69</td>
<td>F</td>
<td>Unknown</td>
<td>Raccoon, eastern United States</td>
</tr>
<tr>
<td>28-Dec-17</td>
<td>14-Jan-18</td>
<td>FL</td>
<td>6</td>
<td>M</td>
<td>Bite</td>
<td>Bat, Tb</td>
</tr>
<tr>
<td>6-Oct-17</td>
<td>21-Oct-17</td>
<td>FL</td>
<td>56</td>
<td>M</td>
<td>Bite</td>
<td>Bat, Tb</td>
</tr>
<tr>
<td>5-May-17</td>
<td>21-May-17</td>
<td>VA</td>
<td>65</td>
<td>F</td>
<td>Bite</td>
<td>Dog, India</td>
</tr>
<tr>
<td>25-Nov-15</td>
<td>1-Dec-15</td>
<td>PR</td>
<td>54</td>
<td>M</td>
<td>Bite</td>
<td>Dog-mongoose, Caribbean</td>
</tr>
<tr>
<td>17-Sep-15</td>
<td>3-Oct-15</td>
<td>WY</td>
<td>77</td>
<td>F</td>
<td>Contact</td>
<td>Bat, Ln</td>
</tr>
<tr>
<td>30-Jul-15</td>
<td>24-Aug-15</td>
<td>MA</td>
<td>65</td>
<td>M</td>
<td>Bite, Philippines</td>
<td>Dog, Philippines</td>
</tr>
<tr>
<td>12-Sep-14</td>
<td>26-Sep-14</td>
<td>MO</td>
<td>52</td>
<td>M</td>
<td>Unknown</td>
<td>Bat, Ps</td>
</tr>
<tr>
<td>16-May-13</td>
<td>11-Jun-13</td>
<td>TX</td>
<td>28</td>
<td>M</td>
<td>Unknown, Guatemala</td>
<td>Dog, Guatemala</td>
</tr>
<tr>
<td>31-Jan-13</td>
<td>27-Feb-13</td>
<td>MD</td>
<td>49</td>
<td>M</td>
<td>Kidney transplant</td>
<td>Raccoon, eastern United States</td>
</tr>
<tr>
<td>6-Jul-12</td>
<td>31-Jul-12</td>
<td>CA</td>
<td>34</td>
<td>M</td>
<td>Bite</td>
<td>Bat, Tb</td>
</tr>
<tr>
<td>22-Dec-11</td>
<td>23-Jan-12</td>
<td>MA</td>
<td>63</td>
<td>M</td>
<td>Contact</td>
<td>Bat, My sp</td>
</tr>
<tr>
<td>3-Dec-11</td>
<td>19-Dec-11</td>
<td>SC</td>
<td>46</td>
<td>F</td>
<td>Unknown</td>
<td>Bat, Tb</td>
</tr>
<tr>
<td>1-Sep-11</td>
<td>14-Oct-11</td>
<td>MA</td>
<td>40</td>
<td>M</td>
<td>Contact, Brazil</td>
<td>Dog, Brazil</td>
</tr>
<tr>
<td>21-Aug-11</td>
<td>1-Sep-11</td>
<td>NC</td>
<td>20</td>
<td>M</td>
<td>Unknown (organ donor)</td>
<td>Raccoon, eastern United States</td>
</tr>
<tr>
<td>14-Aug-11</td>
<td>31-Aug-11</td>
<td>NY</td>
<td>25</td>
<td>M</td>
<td>Contact, Afghanistan</td>
<td>Dog, Afghanistan</td>
</tr>
<tr>
<td>30-Jun-11</td>
<td>20-Jul-11</td>
<td>NJ</td>
<td>73</td>
<td>F</td>
<td>Bite, Haiti</td>
<td>Dog, Haiti</td>
</tr>
<tr>
<td>30-Apr-11</td>
<td>Survived</td>
<td>CA</td>
<td>8</td>
<td>F</td>
<td>Unknown</td>
<td>Unknown</td>
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<tr>
<td>24-Dec-10</td>
<td>10-Jan-11</td>
<td>WI</td>
<td>70</td>
<td>M</td>
<td>Unknown</td>
<td>Bat, Ps</td>
</tr>
<tr>
<td>2-Aug-10</td>
<td>21-Aug-10</td>
<td>LA</td>
<td>19</td>
<td>M</td>
<td>Bite, Mexico</td>
<td>Bat, Dr</td>
</tr>
<tr>
<td>23-Oct-09</td>
<td>20-Nov-09</td>
<td>VA</td>
<td>42</td>
<td>M</td>
<td>Contact, India</td>
<td>Dog, India</td>
</tr>
<tr>
<td>20-Oct-09</td>
<td>11-Nov-09</td>
<td>MI</td>
<td>55</td>
<td>M</td>
<td>Contact</td>
<td>Bat, Ln</td>
</tr>
<tr>
<td>5-Oct-09</td>
<td>20-Oct-09</td>
<td>IN</td>
<td>43</td>
<td>M</td>
<td>Unknown</td>
<td>Bat, Ps</td>
</tr>
<tr>
<td>25-Feb-09</td>
<td>Survived</td>
<td>TX</td>
<td>17</td>
<td>F</td>
<td>Contact</td>
<td>Bat, unknown</td>
</tr>
</tbody>
</table>
Oregon 2000-19

- Cat: 0.12% (2)
- Dog: 0.0%
- Fox: 16% (27)
- Bats 8.3% (226)
- Other: 3 coyote, 1 goat and 1 skunk
Rabies-positive Animals
Oregon, 2020

<table>
<thead>
<tr>
<th>Month</th>
<th>County</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>Lane</td>
<td>Bat</td>
</tr>
<tr>
<td>June</td>
<td>Marion, Benton, Clackamas</td>
<td>Bat</td>
</tr>
<tr>
<td>July</td>
<td>Hood River</td>
<td>Bat</td>
</tr>
<tr>
<td>August</td>
<td>Deschutes</td>
<td>Bat</td>
</tr>
<tr>
<td>September</td>
<td>Marion, Jackson, Marion, Yamhill, Lake, Union, Lane, Lane</td>
<td>Bat</td>
</tr>
<tr>
<td>October</td>
<td>Polk</td>
<td>Bat</td>
</tr>
</tbody>
</table>

Updated: December 2020
Bats!

- 1,400 species
- Only flying mammal
- Can reach 100 mph
- Very longed lived!
  - 20-40 years
Bats

• Resistant to viruses
  – Rabies
  – Ebola
  – Marburg
  – MERS
  – SARS
  – COVID
Bats

• Downregulated immune response
  – Decreased inflammasomes
  – Decrease recognition of DNA

• Why?
  – Flight can induce inflammation
  – Bats live in huge colonies
Bats

- Very effective transmitter of rabies
- Sharp little teeth
- Lick claws
Bat Rabies

- Bat rabies variant
  - More efficient at infecting epithelial cells
  - More efficient at slightly lower temperatures
- Better able to replicate in skin
- Small bites effective
Clinical Rabies

- Incubation
- Prodrome
- Acute neurologic syndrome
- Coma
- Death
Incubation

- Varies!
- Range 12 days – 10 years!
- Median 80 days
- Faster if
  - Bite head/neck
  - Deep wounds
Prodrome

• Wound site
  – Paresthesia, itching, pain
• Limb
  – Radiculopathy
  – Myoclonic jerks
  – Percussion myoedema
  – Choreiform movements
• Viral prodrome
• NPR Radiolab “Rodney vs Death”
Furious Rabies

- Irritability
- Agitation
- Hyperesthesia
- Autonomic disturbances
  - Hypersalivation
  - Sweating
  - Blood pressure swings
Furious Rabies

- Dysautonomia
  - Priapism, cathecholamine surges
- Orofacial dyskinesia
- Can have periods of complete normalcy!
Hydrophobia

• Triad
  – Inspiratory muscle spasm
  – Painful laryngospasm
  – Terror of drinking

• Aerophobia

• Extension arms/legs

• Seizure/cardiac arrest
Paralytic Rabies

- ~ 20%
- More common:
  - Vampire bats bites
  - Incomplete vaccination
- Flaccid paralysis
- Dead due to respiratory arrest
What Kills People in Rabies?

- Mystery!
- Asphyxiation
- Respiratory arrest
- Seizures
- Myocarditis
Differential

• Furious rabies
  – Delirium tremors
  – Drugs
  – Tetanus
    • Shorter incubation
    • No encephalitis
Differential

- Paralytic
  - Guillain-Barre
  - Arbovirus
  - Herpetic simiae (monkey bite)
Diagnosis

• Suspicion!
  – 1/3 diagnosed at autopsy

• Skin biopsy (nape of neck)
  – Immunofluorescence most sensitive
  – PCR being used more now

• CDC
  – Saliva for PCR/viral culture
  – Skin biopsy for PCR/IF
  – CSF for PCR/viral culture
Treatment
Traditional

- Madstones
- Herbal remedies
- Put between two mattresses
- Rooster anus
- Prevention
  - Cauterization
  - Amputation
APPLYING THE MADSTONE TO ARM OF A GIRL WHO WAS BITTEN BY A RABID DOG.
Modern Treatment

OHSU
Treatment

• Palliative Care
  – Sedation/quiet room
  – Benzodiazepines
  – Morphine
  – Anticholinergics
Treatment: Milwaukee Protocol

- 2004 survival unvaccinated patient
- Protocol
  - Therapeutic coma
  - NMDA antagonistic
- Probably never worked again
- Now abandoned
Treatment

- ICU care
- Vaccination
- Antivirals
  - Interferon (IT)
  - Ribavirin
  - Amantadine
- Hypothermia?
“Better” Prognosis

• Young age
• Any type of vaccination
• Mild disease at onset
• Bat variant
The Grim Reality

- 28 survivors
- 5 with no/mild sequelae
- 18 with profound deficits
Prophylaxis

• 16-39,000 people in USA get prophylaxis
Wound Cleaning

• Vigorous wound cleansing with soup and water crucial first step
• HRIG -> vaccinations
• If previous vaccination no HRIG
# Local Therapy

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Infection</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap water</td>
<td>1/19</td>
<td>5.3</td>
</tr>
<tr>
<td>20% soap</td>
<td>2/19</td>
<td>10.5</td>
</tr>
<tr>
<td>Ivory soap</td>
<td>2/20</td>
<td>10</td>
</tr>
<tr>
<td>Benzalkonium</td>
<td>2/20</td>
<td>10</td>
</tr>
<tr>
<td>Ivory soap/serum</td>
<td>2/20</td>
<td>10</td>
</tr>
<tr>
<td>Control</td>
<td>18/20</td>
<td>90</td>
</tr>
</tbody>
</table>

Bull Wild Hth Org 28:477, 1963
Risk Assessment of Bite

• Deep wounds high risk
  – Especially if into muscle
• Face/neck/head wounds
  – Short latent periods
Rabies Immune Globulin

- Humans (horses)
- 20 IU/KG
  - Infiltrated around wound
  - Rest gluteal
- Monoclonal antibodies in development
Vaccination History

- Pasteur – air dried rabbit spinal cords
- Phenol treated spinal cords
  - Large volume shots 10ml
  - Abdomen 14-23 injections
- Human diploid cells
Rabies Vaccine

• **Sources**
  - Human diploid cell lines
  - Chick embryo cells
  - Vero cell
  - Duck embryo cells
• **IM deltoid region**
• **NEVER** gluteal
• **mRNA vaccine in development**
Pre-exposure Prophylaxis

- Occupational risk
- Travel to high risk areas
- Vaccine days 0, 3, 28
Post-Exposure Prophylaxis

• Human rabies immunoglobulin (HRIG)
  – Inject around wound
  – Rest buttocks

• Vaccination
  – Days 0, 3, 7, 14
Rabies Vaccine
IMOVAX® RABIES
PRE- AND POSTEXPOSURE
INTRAMUSCULAR IMMUNIZATION ONLY

NOT FOR INTRADERMAL USE

Wistar Rabies Virus Strain PM-1303.3M-Grown in Human Diploid Cell
Cultures-Single Dose-Lyophilized Vaccine, Luer Syringe with Sterile water, diluent for reconstitution
USP, one needle for reconstitution.

FOR INTRAMUSCULAR INJECTION
When to Prophylaxes

• Bite by wild creature
  – Exception: lagomorphs/small rodents
• Unprovoked pet bites
  – Watch animal for 10 days
Prophylaxis Failure

- Improper wound cleaning
- Inadequate/counterfeit RIG
- Absence of RIG infiltration
- Counterfeit RIG/vaccine
- Vaccine into gluteal region
Risk Assessment

OHSU
Did Animal Exposure Occur?

• Was there a mammal bite?
• Open wound exposure to salvia
• Bats
  – Bite
  – Crawl/lick scratches
Bats Exposure

• Any bat exposure is suspect
  – Any contact
    • Bite, scratch, mucous membrane exposure
  – Same room as bat
    • Sleeping
    • Unattended child
    • Disable/intoxicated person
Transplant

• Corneal transplant
  – Stricter guidelines
• Solid organ transplant
  – Prophylaxis can be effective
Low Risk Wild Animal

- Small rodents, rabbits
- Very rare to have rabies
  - Usually killed by infected larger animal
High Risk

- Bat, raccoon, skunk, woodchuck, coyote, fox
- Test animal
- If not possible prophylaxis
Dog, Cat, Ferret (Pets)

- Healthy
  - 10 day quarantine
    - Gets sick prophylaxis
- Can’t catch
  - Prophylaxis
Small Pets/Livestock

- Always indoors
  - No
- Sometimes outdoors
  - Case by case
- Livestock
  - Case by case
Unprovoked Attack

- Always suspicious!
- Doing dumb things to animals is provocation
Algorithm for Prevention of Rabies After Animal Encounters in Oregon

1. Bat encounter
   - Was there evidence suggesting physical contact? Yes → still live at time of encounter? Yes → is it certain that there was no bite or Oregon? Available for testing? Yes → test
   - No → no test, no PEP

2. Cat bite
   - Evidence that cat is owned? No → certainly provided bite? No → can cat be quarantined? No → test
   - Yes → available? No → no test, no PEP
   - Yes → alive? No → discuss with Epi
     - Definitely unprovoked? No → no PEP
     - Yes → quarantine

3. Dog or ferret bite
   - Available? No → no PEP
   - Yes → alive? No → discuss with Epi
     - Definitely unprovoked? No → no PEP
     - Yes → quarantine

4. Fox or coyote bite
   - Available for testing? Yes → test
   - No → PEP

5. Other animal bite
   - Definitely unprovoked? Yes → available? No → no test, no PEP
     - No → no PEP
   - No → test

Rabies testing in Oregon, 2000-2018

<table>
<thead>
<tr>
<th>Animal</th>
<th>Positive</th>
<th>Tested</th>
<th>% Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bat</td>
<td>200</td>
<td>2332</td>
<td>8.60%</td>
</tr>
<tr>
<td>Cat</td>
<td>2</td>
<td>1488</td>
<td>0.10%</td>
</tr>
<tr>
<td>Dog</td>
<td>0</td>
<td>656</td>
<td>0</td>
</tr>
<tr>
<td>Fox</td>
<td>27</td>
<td>162</td>
<td>16.70%</td>
</tr>
<tr>
<td>Other*</td>
<td>5</td>
<td>688</td>
<td>0.72%</td>
</tr>
</tbody>
</table>

*3 coyotes, 1 goat, 1 skunk
Is Rabies more Common?

• 1/3 diagnosed post-mortem
• Cases missed?
• Epidemiology studies suggest higher infection rate
Non-Lethal Rabies?

• Studies showing both animals and humans with anti-rabies antibodies
  – Nonspecific antibodies
  – Subclinical infection
    • Cleared before CNS invasion
  – Recovery
  – Carrier state
  – Latent period
The Future

• Better antiviral therapy
• Need to understand pathophysiology
• mRNA vaccines
Case Study 1

• Faculty member enjoying a tropical vacation
• Masseuse notices small wounds near ankles
Cast Study 2

• You get a call from one of your co-workers
• While riding a bike, a dog runs across field, lunges at him and bite his legs and runs off....
Rabies

- Terrible way to die!
- Rabies a concern with any mammal bite
- Bats always a concern!
- Wound cleaning key
- Proper prophylaxis