Epidemic Typhus and Other Louse- and Mite-Borne Infections

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Outline

- Louse-borne infections
  - Epidemic typhus
  - Trench fever
  - Relapsing fever
- Mite-borne infections
  - Rickettsialpox
  - Scrub typhus
- General characteristics
  - Life cycle
  - Classification
  - Medical importance
- History of disease
- Etiological agent
- Vector(s)
- Transmission cycle

Lice: general characteristics

- Small, wingless insects
- 4-10 mm long
- Adult lice are dorsal-ventrally flattened
- Elongate with 3 distinct body segments
- Mouthparts adapted for chewing or sucking
- Host-specific

Image courtesy of Michael Groves
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Lice: life cycle

- Hemimetabolous life cycle with 3 immature stages superficially resembling the adult
- Female lice lay <10 eggs/day
- Louse eggs are called "nits"

Louse-borne: life cycle

Lice: classification

Class: Insecta
Order: Phthiraptera
Suborders: Anoplura, Amblycera, Ischnocera (Mallophaga), Rynchophthirina

- 3,200 species of lice described
- 12 families of chewing lice
- 15 families of sucking lice

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Lice: species of medical importance

- The species of greatest medical importance is *Pediculus humanus*
- Lice infestation is still persist in less developed countries

Lice: disease-causing agents

- *Rickettsia*
- *Bartonella*
- *Borrelia*

Organization of louse-borne pathogens

Alpha-proteobacteria

Order: Rickettsiales
- Family: Rickettsiaceae
  - Genus: *Rickettsia*
    - Spotted fever
    - Typhus
  - Orientia
  - Anaplasmataceae
  - Rhizobiales
  - Bartonellaceae
    - *Bartonella*

Order: Spirochaetales
- Family: Spirochaetaceae
  - Genus: *Borrelia*
**Biological characteristics of *Rickettsia***
- Obligate intracellular parasite
- Gram negative bacteria (0.3 x 1 to 2 µm)
- Cocobacillus with complex outer coats with capsule or slime layer
- LPS (weak endotoxin activity)
- Human pathogens
- Virulence factors: unknown
- Transmitted by fleas, lice, mites (ticks)

**Biological characteristics of *Bartonella***
- Facultative intracellular
- Gram negative rod (0.3 x 0.5 µm wide and 1-1.7 µm long)
- Can be grown on axenic media or cocultivated in cell culture
- Transmitted or associated with fleas, lice, and mites (ticks)

**Biological characteristics of *Borrelia***
- Gram negative, long helically coiled (spiral-shaped)
- 0.1 x 0.6 µm wide and 5-250 µm long
- Chemoheterotrophic
- Flagella that run between the cell wall and outer membrane
- Human pathogens
- Transmitted by lice and ticks
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Louse-borne: epidemic typhus

History:
• 1083 – described in Spain
• 1536 – distinguished from plague
• 1700’s and 1800’s – distinguished from typhoid fever
• 1900’s – louse transmission
• 1930 – Zinsser

Image from Roland Huet

Louse-borne: epidemic typhus (2)
Etiological agent: *Rickettsia prowazekii*

Transmission cycle
• Transmission occurs via contamination of bite sites with feces
• Infection through aerosols has also been reported
• Lice also suffer from *R. prowazekii*
• Vertebrate host is necessary for *R. prowazekii* lifecycle

Bechah et al., Lancet Infect Dis. 2008

www.ceen.org/docs/001-613/001-613.html
Louse-borne: trench fever

History:
- Affected >1 million people during World War I
- The name ‘trench fever’ was first mentioned in 1915
- In 1919, transmission by lice demonstrated
- Affected the German army in Russia in World War II
- In 1949, laboratory accident lead to outbreak and precise characterization of the disease
- Sporadic epidemics since World War II
- Reemergence of *B. quintana* among the homeless in Europe and the United States and in refugee camps

Louse-borne: trench fever (2)

Etiological agent: *Bartonella quintana*

- Clinical symptoms include:
  - Headache, dizziness, pain in shins, and elevated temperature
  - 3-7 days post-infection temperature drops; followed by a relapse to fever
- Variable clinical manifestations:
  - Classic with shin pain
  - Typhoid-like with prolonged fever and rash
  - Abortive form, brief, less intense

Louse-borne: trench fever (3)

Transmission cycle
- Between humans and lice:
  - Lice ingest take blood meal from bacteremic host
  - Lice are transmitted between individuals via clothing or bedding
  - *B. quintana* multiplies in the louse’s intestine
  - Subsequent biting of new host results in scratching; thus facilitating fecal transmission of *B. quintana* to uninfected hosts
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Louse-borne: relapsing fever

History:
• Discovered by Otto Obermeier
• Large epidemics in the first half of last century
• 1970’s - cultivated and animal models developed
• 1980’s discovery of antigenic variation

Image modified from Cutler, Clinical Microbiology and Infection, 2009

Louse-borne: relapsing fever (2)

Etiological agent: Borrelia recurrentis

Transmission cycle
• Between humans and lice:
  ➢ Lice ingest blood meal from bacteremic host
  ➢ B. recurrentis mostly destroyed in the louse’s gut, but few persist and move to the hemocoel
  ➢ Lice are transmitted between individuals via clothing or bedding
  ➢ Subsequent biting of new host results in scratching; thus facilitating fecal transmission of B. recurrentis

Image modified from Cutler, Clinical Microbiology and Infection, 2009
Summary

- Louse-borne infections
  - Epidemic typhus
  - Trench fever
  - Relapsing fever
- Lice transmitted between people via clothes/bedding
- Agents are transmitted to vertebrates during feeding via fecal transmission
- While less prevalent, important for stressed populations

Outline

- Louse-borne infections
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- Mite-borne infections
  - Rickettsialpox
  - Scrub typhus
  - General characteristics of mites
  - Species of medical importance
  - Disease-causing agents

Mites: general characteristics

- Typically less than 1 mm long
- Abdomen joined to cephalothorax, no segmentation
- Chelicerae for tearing or piercing in parasitic species
- Feeding chiggers inject a salivary fluid which dissolves the host's cells, then suck up the liquefied tissue; Within a few hours, small, reddish, intensely itching welts appear
- These bites may continue to itch for several days up to two weeks after the chigger is dislodged
- Inhabit areas of tall grass, associated with wet spots, ponds and stream banks, and forest underbrush
- Larvae attach to passing animals; On humans, typically move to a part of body that is constricted, e.g., waistband
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Mite: life cycle

Image by Rebecca L. Nims, from Medical and Veterinary Entomology Eds. Mullen and Durden

Mites: classification

Class: Arachnida
Subclass: Acari
Order: Prostigmata

Source: http://tolweb.org/tree/phylogeny.html

Mites: species of medical importance

- Free-living, predaceous and parasitic – ectoparasites
- Indirect and direct effects on humans and animals:
  - Dermatitis or other tissue damage
  - Cause of strong allergic reactions
  - Loss of blood
  - Transfer of pathogenic agents

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Mites: disease-causing agents

- Rickettsia
- Orientia

Mite-borne: rickettsialpox

History:
- First described in 1946 – Queens epidemic
- Characterization – from isolation of the agent to published description as causative agent of disease was 5 months
- 2001-2003 – an increase in cases due to increased laboratory conformation

Etiological agent: Rickettsia akari

Image courtesy of Christopher Faddis
Mite-borne: rickettsialpox (3)

Vector: *Liponyssoides* mite vector

Image courtesy of Christopher Paddock

Mite-borne: rickettsialpox (4)

Transmission cycle: House mite (vector) → House mouse (maintenance host) → Human

Image modified from Azad and Beard, EID, 1996

Mite-borne: scrub typhus

History:

Image taken from medscape.com

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Mite-borne: scrub typhus (2)

Etiological agent: *Orientia tsutsugamushi*

Infection: *Orientia tsutsugamushi*

Scrub typhus: eschar

Image courtesy of Michael Groves
Scrub typhus: eschar and rash

Images courtesy of Michael Groves

Mite-borne: scrub typhus

Vector: Trombiculid mites

Images courtesy of Michael Groves
Image by Rebecca L. Nims, from Medical and Veterinary Entomology Eds. Muller and Durham

Scrub typhus: transmission cycle
Scrub typhus: transmission cycle (2)

Image courtesy of Michael Groves

Scrub typhus: mites on rodents

Images courtesy of Michael Groves

Scrub typhus: mite habitat

Images courtesy of Michael Groves
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Scrub typhus: mite habitat (2)

Image courtesy of Michael Groves

Scrub typhus

Image courtesy of Michael Groves

Scrub typhus (2)

Image courtesy of Michael Groves

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Summary

• Mite-borne infections
  ➢ Rickettsialpox
  ➢ Scrub typhus

• Only larval ‘chigger’ stages are parasitic
• Agents are transmitted to vertebrates during feeding via salivary secretions

Acknowledgements

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