Wound Infections
Lecture 20 - Dr. Gary Mumaugh

Wound Infections
- Disease production in infected wounds depends on
  - How virulent infecting organisms are
  - How many organisms infect the wound
  - Is the host immunocompetent
  - Nature of the wound
    - Does it contain crushed material or foreign material
      - Such wounds do not heal until foreign material is removed

Wounds can be classified as
- Incised (incision) - Produced by a knife or other sharp object
- Puncture - From penetration of a small sharp object
- Lacerated (laceration) - When tissue is torn
- Contused (contusion) - Injury caused by a blow
- Burn - a.k.a thermal burn

Wound Abscesses
- A localized collection of pus surrounded by body tissue
- Abscess formation helps to localize infection
  - Microorganisms in abscesses are potential source of infection if they escape from localized area
- To effect cure, abscess must rupture to a body surface or be surgically drained

Common Bacterial Wound Infections
- Common bacterial wound infections include
  - Staphylococcal wound infections
  - Group A Streptococcal wound infections
  - *Pseudomonas aeruginosa* infections
- Consequences of wound infection include
  - Delay in healing
  - Formation of abscess
  - Extension of bacteria or their products to adjacent tissues or bloodstream

Staphylococcal Wound Infections
- Staphylococci are leading cause of wound infections
- Bacteria commonly present in nose and on skin
- More than 30 recognized strains
  - Two account for most human infections
    - *S. aureus*
    - *S. epidermidis*
Staphylococcal Wound Infections

- **Symptoms**
  - Bacteria are pyogenic
    - Produce pus
  - Infection causes
    - Inflammation
    - Fever in cases where infection has spread
  - Some strains produce toxic shock syndrome

- **Causative Agent - Staphylococci**
  - Gram-positive cocci in clusters
  - Grow aerobically or anaerobically (facultative)
  - Salt tolerant
    - Allows survival in numerous foods
Staphylococcal Wound Infections

- Causative Agent - Staphylococci
  - Most important species are
    - *S. aureus* and *S. epidermidis*
      - Both survive well
      - Easy to transfer from person to person

- Causative Agent - *S. aureus*
  - Virulence due to the production of extracellular products
    - Coagulase - Causes blood clotting to evade phagocytosis
    - Clumping factor - Aids in bacterial wound colonization
    - Protein A - Hide bacteria from phagocytic cells
  - Pathogenesis - *S. aureus*
    - Multiple virulence factors produce signs of infection
      - Clumping factors coagulase and protein A
        - Attach organism to clots and tissue
        - Coat organism with host protein
        - Hide from phagocytosis
    - Systemic spread can lead to abscesses in other tissue
      - Commonly heart and joints
    - Certain species produce toxins
      - Toxin in blood acts as superantigen
        - Can lead to toxic shock syndrome

- Causative Agent - *S. epidermidis*
  - Bacteria have little or no invasive ability
    - Maintained on skin surface
    - Introduced into body from wound
      - Example: surgical incision
    - Internalized strains bind and allow colonization of indwelling devices
      - Colonization produces biofilm which protects organism from phagocytosis
  - Pathogenesis - *S. epidermidis*
    - Infections usually cleared by healthy immune system
    - Organisms can migrate to heart and other tissues
      - Organisms from biofilms carried in bloodstream
      - Can cause subacute bacterial endocarditis or multiple tissue abscesses
        - Generally in immunocompromised

- Epidemiology
  - Nasal carriers 2 to 7 times greater risk of surgical wound infection
    - 30% to 100% due to patient's own flora
  - Factors associated with infection include
    - Advanced age
    - Immunosupression or poor general health
    - Prolonged postoperative hospital stay
Staphylococcal Wound Infections

- Prevention
  - Prevention of infection is directed at
    - Cleansing wound
    - Removing dirt and crushed tissue
    - Prompt closure
    - Pre-surgical antistaphylococcal medication
      - Surgical wound infections reduced by half

- Treatment
  - Treatment can be problematic
    - Many strains develop resistance to antibiotics
      - Most strains are resistant to penicillin
    - Many strains treated with anti β lactamase penicillins and vancomycin
      - Vancomycin resistant strain identified in 1997

Group A Streptococcal Infections

- Also known as “flesh eaters”
- Primary pathogen is
  - S. pyogenes
  - Can cause rapidly deteriorating disease and death
  - Not a lot of antimicrobial resistance
- More severe infections called invasive
- Include
  - Pneumonia
  - Meningitis
  - Puerperal (childbirth fever)
  - Necrotizing fasciitis (flesh eating disease)
  - Streptococcal toxic shock
- Symptoms
  - Acute pain at the site of the wound
  - Swelling
  - Fever and confusion
  - Overlying skin tightens and becomes discolored
  - Shock and death - In the absence of treatment
- Causative Agent - S. pyogenes
  - Some strains cause invasive infection
    - These are more virulent than strains that do not
- Pathogenesis
  - Subcutaneous fascia is destroyed in necrotizing fasciitis
    - Muscle tissue is also destroyed when bacteria penetrate muscle tissue
  - Organisms multiply and produce toxic products
    - Organisms and toxic products enter bloodstream - Can cause shock
Group A Streptococcal Infections

- Epidemiology
  - “Flesh eating” infections have been described since the 5th century B.C.
    - 2,000 cases reported during Civil War
  - Cases generally sporadic
    - Small epidemics have occurred
    - Outbreak in San Francisco in 1996
      - Traced to use of contaminated “black tar” heroine
  - Approximately 9,000 cases of invasive
    - *S. pyogenes* in 2002
    - Resulted in 1080 deaths
    - 135 from necrotizing fasciitis

- Prevention and Treatment
  - No proven prevention measures
  - Urgent surgery required due to rapidity of toxin spread
    - Amputation is sometimes required
  - Penicillin is still an effective treatment
    - Must be given early
    - Has little or no effect on bacteria in necrotic tissues
    - No effect on toxin
    - Surgery may still be necessary

Pseudomonas aeruginosa Infections

- *P. aeruginosa* is an opportunistic pathogen
- Major cause of nosocomial infections
  - Occasional cause of community acquired infections
- Nosocomial infections include
  - Lung infections
  - Burn infections
- Community acquired infections include
  - Rash and external ear infections
    - Obtained from contaminated swimming pools and hot tubs
  - Infection of foot bones
  - Eye infections
  - Heart valve infections
  - Lung biofilms

- *Pseudomonas aeruginosa* Symptoms
  - Change in tissue color
    - *P. aeruginosa* releases pigments that often color tissues green
  - Chills, fever, skin lesions and shock
    - Caused by bacterial infection in bloodstream
**Pseudomonas aeruginosa**
- Causative Agent - *Pseudomonas aeruginosa*
  - Generally aerobic
  - Produces numerous pigments that produce color change in tissues
- Pathogenesis
  - Overall effect is tissue damage, prevention of healing and increased risk of septic shock
  - Some strains produce enzymes and toxins to enhance virulence
- Epidemiology
  - *P. aeruginosa* is widespread in nature
    - Found extensively in soil, water and on plants
  - Introduced in hospitals, on the soles of shoes, on ornamental plants and flowers and on produce
  - Bacteria will persist in dampness or standing water
  - Contaminates soaps, ointments, eye drops, swimming pools and hospital equipment
- Treatment
  - Prompt wound care
  - Removal of dead tissue from burns
    - Followed by application of antibacterial cream
    - Silver sulfadiazine
  - Established infections are extremely difficult to treat
    - *P. aeruginosa* is multi-drug resistant
  - Medications must be administered intravenously at high doses

**Tetanus**
- Also know as “Lockjaw”
- Frequently fatal; however, rare in the developed world
- Bacterial spores prevalent in dust and soil
  - Difficult to avoid exposure
- Symptoms
  - Divided into early and late symptoms
  - Early symptoms
    - Restlessness
    - Irritability
    - Difficulty swallowing
    - Contraction of jaw muscles
    - Convulsions
      - Particularly in children
Tetanus

- Symptoms
  - Later symptoms
    - Increased muscle involvement
    - Pain
    - More muscle involvement creates more severe pain
    - Difficulty breathing
      - Often leads to development of pneumonia
    - Death
      - Due to pneumonia
      - Regurgitation of stomach contents into lungs

- Causative Organism - *Clostridium tetani*

- Pathogenesis
  - Colonization is generally contained to wound
  - Bacteria produce toxin
    - Toxin = tetanospasmin
    - Toxin is responsible for pathological effects
  - Tetanospasmin blocks inhibition of motor neurons, causing paralysis
    - Muscle contraction is uncontrolled
      - Muscles do not relax
      - Paralysis usually begins in the jaw

Tetanus - Epidemiology

- *C. tetani* found in dirt and dust and gastro intestinal tract of humans and other animals
- Nearly half of infections result from puncture wounds including
  - Body piercing, tattooing, animal bites, injected drug abuse
- 30 to 60 cases in United States annually with 25% mortality rate
- Immunization has decreased incidences in economically advanced countries ------ Infection more common in developing countries

- Prevention
  - Immunization best preventative
    - Vaccine is inactivated tetanospasmin
      - DPT Given in combination with diphtheria and pertussis vaccine

Tetanus - Treatment

- Thoroughly clean wound
  - Remove all dead tissue
- Antimicrobial treatment given to kill multiplying bacteria
- Metronidazole
  - Antimicrobials do not kill endospores
- Antitoxin - antibody against tetanospasmin
  - Neutralizes toxin not attached to nerve cells
Clostridial Myonecrosis – Gas Gangrene
- Endospores of causative bacillus are innumerable
  - Spores found in nearly all soil or dusty surface
- Primarily disease of wartime
  - Due to neglected wounds containing debris

Gas Gangrene Symptoms
- Begin abruptly
- Rapidly increasing pain
  - Pain localized to area of wound
- Increased swelling
- Thin, bloody fluid leaks from wound
  - Fluid is often brownish and may appear frothy
    - Frothy appearance is due to gas production by infection bacteria
- Skin becomes stretched and mottled with black spots
- Patient appears very ill but alert
  - Delirium and coma occur late in illness followed by death
Gas Gangrene

- **Causative Agent**
  - Several species of *Clostridium*
    - Most common offender, *C. perfringens*
  - Two factors foster development of clostridial myonecrosis
    - Presence of dirt and dead tissue in wound
    - Long delays in treatment
      - Immediate medical attention in severe wound is especially important

- **Pathogenesis**
  - Bacteria is a toxin producer
    - Toxin attacks host cell membrane
      - Toxin diffuses and kills tissue cells
  - *C. perfringens* unable to grow in healthy tissue
    - Survives well in dead or poorly oxygenated tissue
    - Releases toxin in tissue
  - Bacteria produces gas through fermentation
    - Gas accumulates in tissue, contributing to spread

- **Epidemiology**
  - *C. perfringens* found in feces
    - Of humans and animals
  - Present in vaginal tract
    - Established in the vaginal tract of 1% to 9% of healthy women
  - Gas gangrene of uterus
    - Fairly common after self-induced abortion
    - Rarely seen after miscarriage and childbirth

- **Prevention**
  - Vaccine unavailable
  - Prompt cleaning and debridement of wound
  - Surgical removal of dead and damaged tissue
    - Highly effective at preventing disease

- **Treatment**
  - Treatment depends primarily on prompt removal of affected tissue
    - Amputation may be required
  - Hyperbaric oxygen treatment
    - Inhibits growth of clostridia
      - Stops release of toxin
  - Penicillin is given to halt bacterial growth
    - No growth = no toxin production
Actinomycosis – “Lumpy jaw”

- **Symptoms**
  - Progresses slowly
  - Sometimes includes painful swelling under the skin
  - Swollen regions open and drain pus
    - Chronic condition
    - Openings usually heal
    - Lesions reappear at the same or nearby region within days or weeks
  - Most cases involve the jaw or neck
    - Recurrent lesions may develop on chest and abdominal wall or genital tract of women
  - Scars and swelling give rise to name “lumpy jaw”

- **Pathogenesis**
  - *A. israelii* cannot penetrate healthy mucosa
    - Disease progresses to skin and can penetrate bone or central nervous system
    - In tissue, culture grows as dense yellow colonies
      - Good identifier for diagnosis
      - Nearly 50% of cases originate in mouth
**Actinomycosis – “Lumpy jaw”**

- Epidemiology
  - Can be normal flora
    - Found in mouth mucosa, upper respiratory tract, intestine and vagina
    - Commonly found in gingival crevices
  - Disease is sporadic and non-communicable
- Prevention and Treatment
  - No proven prevention
  - Responds to numerous antibacterials
    - Penicillin and tetracycline
    - Treatment must be given orally for several weeks or months
    - This is due to the slow growing nature of the organism

**Pasteurella multocida**

- Responsible for bite infections from numerous animals including
  - Dogs
  - Cats
  - Monkeys
  - Humans
- More common than rabies
- Symptoms
  - No reliable symptoms that distinguish one bite from another
  - Generalized symptoms include
    - Spreading redness
    - Tenderness
    - Swelling of adjacent tissues
    - Pus discharge

**Pasteurella multocida**

- Epidemiology
  - Best known as cause of devastating chicken disease
    - Fowl cholera
  - Also causes disease in a number of other animals
    - Epidemics of fatal pneumonia in rabbits, cattle, sheep and mice
  - Healthy animals carry organism as part of oral and respiratory normal flora
    - Diseased and healthy animals act as reservoir for human infection
- Prevention and Treatment
  - No vaccine available for human use
  - Immediate cleansing and prompt medical attention
    - Usually prevents development of serious infection
  - Organism is susceptible to penicillin
    - Usually Augmentin is administered before diagnosis
    - Other antibacterials are effective if given early
Cat Scratch Disease

- **Symptoms**
  - Disease begins within a week of scratch or bite
  - Development of pus-filled pimple
  - Painful enlargement of lymph nodes
    - Nodes at region of wound enlarge in 1 to 7 weeks
    - In about 50% of patients, nodes become pus filled
  - Fever
    - Fever develops in about one-third of patients
  - Disease is self-limiting
    - Disease disappears in about 2 to 4 months
  - 10% of cases develop eye irritation
    - With local lymph node enlargement
  - Encephalitis can be a complication
    - Seizures and coma can result
  - Acute or chronic fever are associated with blood stream or heart valve infection

- **Pathogenesis**
  - Virulence factors and disease process are not understood
  - Organism enters body through scratch or bite
  - Carried to the lymph nodes
    - Disease is arrested by immune system in most cases with systemic spread in some individuals
  - Complicating conditions can occur mostly in immunocompromised

- **Epidemiology**
  - Mainly occurs in people under the age of 18
  - Zoonotic disease
    - Particularly from cats to humans
      - Mainly by kittens
    - Cats infected by bite of flea
  - Person-to-person spread does not occur
  - Bites and scratches usual mode of transportation
  - Asymptomatic bacteremia common in cats

- **Prevention and Treatment**
  - No proven prevention methods
  - Avoid handling stray cats
  - Promptly clean wound with soap and water
    - Then treat with antiseptic
  - Prompt medical evaluation with signs of infection
  - Infections usually treated with ampicillin
  - Some strains are resistant
Human Bites

- Symptoms
  - Wound may appear insignificant
  - Painful with massive swelling
  - Pus discharge
    - Pus often foul smelling
  - Most wounds are on exterior of hand
    - Swelling may involve palm
    - Movement may be hampered

- Pathogenesis
  - Mouth flora generally harmless
    - Produce numerous toxins and enzymes
      - Toxins and enzymes destroy tissues and immune complexes

- Epidemiology
  - Most serious human bite results from violent altercations
  - Risk of infection increases when biting individual has poor oral hygiene
    - Bites by small children are usually inconsequential
  - Most serious human bite results from violent altercations
  - Risk of infection increases when biting individual has poor oral hygiene
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- Prevention
  - Avoid situations that may lead to altercation
  - Prompt cleaning
  - Application of antiseptic
  - Immediate medical attention if infection becomes evident

- Treatment
  - Medical treatment consists of
    - Opening wound
    - Washing with sterile fluid such as saline
    - Removal of dirt and dead skin
    - Use of antibacterial medication
      - Effective against anaerobes

Sporotrichosis
- Also known as “rose gardener’s disease”
- Distributed worldwide
- Associated with puncture wound from vegetation
- Sporadic
  - Occurs in specific occupations
  - Epidemics have occurred in United States
Sporotrichosis

• Symptoms
  o Hand or arm primary site of involvement
    ▪ Trunk, legs and face can also be infected
  o Chronic ulceration occurs at site of wound
  o Development of ulcerating nodules
    ▪ Develop sequentially towards center of body
  o Lymph node enlargement
  o Healthy individuals rarely become ill
    ▪ Can be life threatening to immunocompromised

• Pathogenesis
  o Spores introduced via injury caused by plant material
  o Incubation period ranges 1 to 3 weeks
  o Small nodule forms
    ▪ Due to multiplying fungi
  o Lesion enlarges
    ▪ Ulcerates and produces red, bleeding skin defect

• Epidemiology
  o Fungi distributed worldwide
    ▪ Mostly in warmer and temperate regions
    ▪ Mostly in Mississippi and Missouri River Valley in United States
  o Occupational disease of
    ▪ Farmers
    ▪ Carpenters
    ▪ Gardeners and Greenhouse workers
  o Not reported – incidence unknown
  o Risk factors of disease include
    ▪ Diabetes, immunosuppression and alcoholism

• Pathogenesis
  o Ulceration process repeats itself
  o Disease progression usually follows flow of lymphatic vessel
  o In healthy individuals process does not proceed beyond lymph
  o Without treatment disease becomes chronic node

• Prevention and Treatment
  o Protective clothing
    ▪ Gloves and long-sleeved shirt
  o Disease is often misdiagnosed
    ▪ Leads to delayed and inappropriate treatment
    ▪ Usually cured with oral potassium iodide (KI)
      ▪ Enhances body’s ability to reject fungus
    ▪ Itraconazole and amphotericin B used in rare cases
      ▪ Generally when disease is systemic