Infection

Kathya Zinszer, DPM, MPH, MAPWCA

The Comprehensive Wound Care Review Course

Endorsed:

AMERICAN PROFESSIONAL WOUND CARE ASSOCIATION
Risk Factors for Wound Development

- Peripheral motor neuropathy
- Peripheral sensory neuropathy
- Peripheral autonomic neuropathy
- Neuro-osteoarthropathy
- Vascular (arterial) insufficiency
- Hyperglycemic and other metabolic disorders
- Patient disabilities: Immobility, Paralysis, Spasticity
- Maladaptive patient behaviors
- Health care system failures
Evaluation of the Infected Patient
Clinical Assessment

➢ Local Response
  • Redness, warmth, induration, pain, drainage, odor
  • <2 cm

➢ Systemic Response
  • Fever, chills, sweats, vomiting, hypotension, tachycardia
  • History and Physical Exam

Endorsed:
Wound Assessment

- Wound Type
- Exudate Type, Amount
- Size, Depth
- Wound Base
  - Red Granulation Tissue
  - Yellow Slough/Fibrin
  - Black Necrotic Tissue
- Undermining
- Edges
- Periwound Skin
- Edema Type, Amount
- Assessment of Bioburden

Endorsed by:

American Professional Wound Care Association
Evaluation

➢ Metabolic State

- Volume depletion, azotemia, hyperglycemia, tachypnea, hyperosmolality, acidosis
- Serum chemistry analysis, hematological testing should include but not be limited to:
  - FBG, HgA1c
  - BUN
  - Creatinine
  - UA
  - Albumin/Globulin ratio
  - Total protein
  - Total albumin
  - CBC & Differential
  - ESR
- Albumin <30 g/L = delayed healing, <20 g/L = inability to heal
- HgB < 100 g/L = delayed healing, <70 g/L = inability to heal

Endorsed:

[Logo: APWCA]
Evaluation

➢ Arterial Vascular Status
  • Ischemia, necrosis, gangrene
  • Foot pulses, ABI(> .5),
    • PVRs, TBI (>30 mmHg),
    • TcpO2 (>40mmHG, 20mmHg=20% chance of healing)

➢ Venous vascular status
  • Edema, stasis, thrombosis
  • Skin and soft tissue examination, duplex ultrasonography

➢ Biomechanics

➢ Neuropathy

➢ Psychological/cognitive state

➢ Social situation

Endorsed:
Infection

Presence of Infection

- **Classic Signs**: erythema (rubor), warmth (calor), tenderness, purulent drainage, pain (dolor), and swelling (tumor)
- **Secondary signs**: delayed wound healing over time, friability and discoloration of granulation tissue, pocketing at the base of the wound, foul odor, wound breakdown, increase drainage, and increased pain
- **Other signs**: Induration, bullae, crepitus, abscess, fasciitis, osteomyelitis
How do I know if the wound I'm treating is infected?

➢ Is the patient febrile? If not are they Diabetic?
➢ Does the wound appear red and swollen and is the area around the wound warm?
➢ Is there purulent drainage or a foul odor?
➢ Is bone exposed or possible probe to bone?
➢ Laboratory tests:
  • White blood cell count (WBC), erythrocyte sedimentation rate (ESR), c-reactive protein (CRP)
  • Gram Stain, blood cultures x 3
  • X-Ray, CT, MRI
  • Wound culture (Levine semi-quantitative technique)
  • Deep tissue culture (not swab Biopsy: tissue, bone Quantitative technique)

Endorsed by Nuclear medicine testing WBC labeling (gallium, technetium indium scans)
## Most Common Gram +/- Bacteria

### Gram Positive
- Streptococcus Group A,B,C,G
- Streptococcus pneumoniae
- Streptococcus viridans
- Streptococcus milleri
- Enterococcus faecalis
- Enterococcus faecium
- Staphylococcus aureus
  - MRSA
  - MSSA
- Staphylococcus epidermidis
- Corynebacterium jeikeium
- Listeria monocytogenes

### Gram Negative
- Acinetobacter sp.
- Providencia sp.
- Aeromonas sp.
- Pseudomonas auer
- Citrobacter sp.
- Salmonella sp.
- Enterobacter sp.
- Serratia sp.
- Escherichia coli
- Shigella sp.
- Haemophilus influenzae
- Klebsiella sp.
- Stentotrophomonas
- Moraxellae catarrhalis
- maltophilia
- Morganella sp.
- Yersinia enterocolitica
- Neisseria gonorrhea
- Neisseria meningitidis
- Proteus mirabilis
- Proteus vulgaris

Endorsed:

[APWCA](https://www.apwca.com)
Aerobic vs Anaerobic Bacteria

**ANAEROBES**

- Actinomyces
- Bacteroides fragilis
- Clostridium difficile
- Clostridium perfringens
- Peptostreptococcus sp.
- Prevotella melanigenica

**AEROBES**

- Everything Else!
  - If you memorize the Anaerobes then you pretty much know that everything else is for the most part AEROBIC
Common Bacterial Pathogens in Wounds

➢ Diabetic Ulcers:
  • E. coli
  • Enterococcus Group D Streptococcus
  • Group B Streptococcus
  • Proteus species
  • Staph aureus

➢ Pressure Ulcers:
  • E. coli
  • Enterococcus (VRE)
  • Klebsiella species
  • Proteus species
  • Pseudomonas aeruginosa
  • Staph aureus (MRSA)
Common Bacterial Pathogens in Wounds

➢ **Cellulitis:**
  - Staphylococcus aureus
  - Streptococcus
    - Groups A, C, G

➢ **Necrotizing Fasciitis**
  - Streptococcus
    - Groups A, G

➢ **Burns:**
  - Candida
  - Enterobacter cloacae
  - Enterococcus (VRE)
  - Klebsiella sp
  - Pseudomonas aeruginosa
  - Serratia marcescens
  - Staph aureus

Endorsed:

[APWCA Logo]
Definition of Infection: “The presence of replicating microorganisms within a wound with subsequent host injury. Wound infection is far less common than wound colonization & contamination”. Chronic Wound Care, Gordon Dow
Definitions

➢ **Wound Contamination**: the presence of non-replicating organisms in the wound.

➢ All chronic wounds are contaminated.
  • All diabetic foot wounds are “contaminated”
  • Many of those wounds become “critically colonized” with a high bio burden with $>10^5$ microorganisms per gram of tissue

➢ These contaminants come from the indigenous microflora and/or the environment.

➢ Most contaminating organisms are **not** able to multiply in a wound.

Endorsed: • (i.e. Most organisms in the soil won’t grow in a wound).
Definitions

➢ Wound Colonization: the presence of replicating microorganisms **adherent** to the wound in the **absence of injury to the host**.

➢ This is also very common.

➢ Most of these organisms are normal skin flora:
  - *Staphylococcus epidermidis*,
  - Other coagulase negative Staph.
  - *Corynebacterium* sp.
  - *Brevibacterium* sp.,
  - *Propionibacterium acnes*,
  - *Pityrosporum* sp..
Definitions

➢ Wound Infection: the presence of replicating microorganisms within a wound that cause host injury, local or systemic.

➢ Primary pathogens of concern:

  - *Staphylococcus aureus*,
  - Beta-hemolytic *Streptococcus (S. pyogenes, S. agalactiae)*,
  - *E. coli*
  - *Proteus*
  - *Klebsiella*
  - *Pseudomonas*
  - *Acinetobacter*
  - *Stenotrophomonas (Xanthomonas)*
  - Anaerobes,
From Colonization to Infection?

Many factors affect the progress of microorganisms in a wound from colonization to infection:

- Infection or Presence of Disease = \text{dose} + \text{virulence} + \text{host resistance}
- The number of organisms/bacteria (dose)
- The virulence factors they produce.
- The resistance of the host to infection.

Endorsed:
Dose of Bacteria

➢ Differs depending on the organism involved.
➢ Some organisms would need to be in high concentrations. (ex. *Candida, Enterococcus*)
➢ Various combinations of bacterial species result in more host damage (synergy)
➢ Example; Group B *Streptococcus (S. agalatiae)* and *Staphylococcus aureus*.

Endorsed:
Bacteria grow in various forms:

- **Planktonic:**
  - Free-floating
  - Most antibiotic testing is on planktonic
  - Antibiotics can affect/kill easier

- **Biofilms**
  - Embedded in the Extracellular Polysaccharide Matrix
  - Complex communities of bacteria as well as other organisms that adhere form a “film” on solid surfaces
  - Can survive in hostile environments, using channels in which circulation of nutrients can occur as well as waste disposal
Dose of Bacteria

Organisms that should be treated regardless of quantity:

- Bacillus anthracis
- Beta-hemolytic streptococci
- Brucella sp.
- Clostridium sp.
- Corynebacterium diphtheriae
- Dimorphic fungi
- Erysipelothrix rhusiopathiae
- HSV (herpes simplex virus)
- Leishmaniasis.
- Leptospira sp.
- Mycobacteria sp.
- Treponema sp.
- VZV (varicella zoster virus)
- Yersinia pestis
Host Resistance

➢ This is the single most important determinant in wound infection.
➢ **Local** and **Systemic** factors both play a role in increasing the chances a wound will become infected.

Endorsed:
## Host Resistance
### Factors that Increase Risk of Wound Infection

<table>
<thead>
<tr>
<th>Local Factors</th>
<th>Systemic Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large wound area</td>
<td>Vascular disease</td>
</tr>
<tr>
<td>Increased wound depth</td>
<td>Diabetes</td>
</tr>
<tr>
<td>Degree of chronicity</td>
<td>Edema</td>
</tr>
<tr>
<td>Anatomic location (distal extremity, perineal)</td>
<td>Malnutrition</td>
</tr>
<tr>
<td>Foreign body</td>
<td>Alcoholism</td>
</tr>
<tr>
<td>Necrotic tissue</td>
<td>Prior surgery or radiation</td>
</tr>
<tr>
<td>Mechanism of injury (bites, perforated viscus)</td>
<td>Corticosteroids</td>
</tr>
<tr>
<td>Reduced perfusion</td>
<td>Inherited neutrophil defects</td>
</tr>
</tbody>
</table>

Endorsed:

[APWCA](https://www.apwca.org)
Progression of Bacterial Damage

Low Risk

➢ Contaminated or Colonized
➢ Bacteria present on the wound surface
➢ Replicating organisms attaching to the wound surface but *NOT* associated with tissue damage or delayed healing (colonization)

Medium Risk

➢ Critical colonization, covert infection, increased bio burden
➢ Initiates the body’s immune response (Inflammation)
➢ Wound healing delayed, closure stalled
➢ **NERDS**
  • Non-healing,
  • Exudative wound
  • Red and bleeding
  • Debris in wound
  • Smell

Endorsed:

[Image: APWCA Logo]
Progression of Bacterial Damage

High Risk

- Bacteria spread to deeper surrounding tissue
- Associated surrounding host inflammatory response and local tissue damage
- Painful with increase in size and new satellite areas of breakdown

STONEES:
- Size increased
- Temperature increased
- Os (probes to bone)
- New areas of breakdown
- Exudate, Erythema, Edema
- Smell

Endorsed by:

[Logo]

American Professional Wound Care Association
Pathogens Associated with Various Clinical Foot-Infection Syndromes

➢ A chronic infected wound or one that was previously treated with an antibiotic
  • Staph aureus, Beta-hemolytic strep, Enterobacteriaceae

➢ Long-duration non-healing wounds with prolonged exposure to Broad Spectrum antibiotics
  • Aerobic gram+ cocci (S. aureus, Coag - staph, and enterococci),
  • Diptheroids,
  • Psuedomonas species
  • Non-fermentative gram(−)rods, and possibly fungi

➢ Infected wound in a patient without previous exposure to an antibiotic
  • Staph aureus
  • B-hemolytic strep

➢ Ulcer that has become macerated because of soaking

Endorsed: Pseudomonas aeruginosa
Pathogens Associated with Various Wound Infection Syndromes

➢ Fetid Foot: extensive necrosis or gangrene
  • Mixed aerobic gram+ cocci,
  • Including enterococci, Enterobacteriacea,
  • Non-fermentative gram (−)rods and
  • Obligate anaerobes

➢ Cellulitis *without* and open skin wound
  • B-hemolytic strep
  • Staph aureus
Multiple Exposures to Broad Spectrum Antibiotics can lead to Resistant Bacteria

- Methicillin resistant Staph aureus MRSA
- Vancomycin resistant enterococci VRE
- Vancomycin resistant S. aureus

Polymicrobial Infections

Diabetic foot wounds generally yield 3-5 different microorganisms
Topical Antiseptics

➢ Used for maintenance for non-healable wounds
➢ Do not debride, avoid moist wound healing
➢ Goals: decrease local bacterial count, prevent bacterial invasion

Ideal Topical Agent

➢ STAR
  • not used Systemically
  • low Tissue Toxicity
  • non – Allergic
  • low incidence of bacterial Resistance

Endorsed:
Topical Antiseptics

- Chlorhexidine ➢ Broad spectrum/low toxicity
- Povodine-iodine* ➢ Broad spectrum/low toxicity
- Acetic acid ➢ Pseudomonas
- Dyes: Scarlet red ➢ Gram + bacteria alone
  Proflavine
- Na Hypochlorite ➢ Toxic to granulation tissue
  Dakin’s, Eusol *
- Hydrogen peroxide ➢ Effective only when effervescent
- Quaternary ammonia: ➢ Very Toxic
  Cetrimide

* Some controversy believed to be able to use for short time on wounds
Avoid Gentamycin and Tobramycin

➢ May be used intravenously in certain resistant organisms
➢ Topical use may result in development of resistant species and preclude the use of the antibiotic later

Neomycin and Bacitracin

➢ Associated with strong allergic sensitivity

Endorsed:
Preferred Topical Agents

- Silver sulfadiazene
- Metronidazole
- Gramicidin
- Polymyxin creams
  - Avoid ointment vehicles that contain Bacitracin
- Ionic or Nanocrystalline silver dressings
- Polyhexamethylene biguanide
- Cadexomer iodine
- Methylene blue

Endorsed:

[APWCA logo]
Systemic Antibiotics

➢ The present literature does not support the use of antibiotics for the management of clinically uninfected ulcerations either to enhance wound healing or as prophylaxis against infection

- Risk of antibiotic resistance
- Added financial burden
- Risk of drug related adverse effects
Who Should Be Hospitalized?

➢ Patients with severe infections or those complicated by Critical Limb Ischemia (CLI)
➢ What constitutes a severe infection?

Classification of a Foot Infection

- **PEDIS**: Perfusion, Extent/size, Depth/tissue loss, Infection, Sensation
  - Mild: PEDIS grade 2 (Grade 1 is Uninfected)
  - Moderate: PEDIS 3 Systemically well & metabolically stable
  - Severe: PEDIS 4 Systemic Toxicity or Metabolic Instability
Choice of Antibiotic

Initial Therapy

- Empirically based on the severity of the infection and available culture or gram stain information
- Begin therapy with broad spectrum agents with activity against gram(+) cocci
- Consider MRSA in locations where this is common and you could treat with the following:
  - Linezolid + Aztreonam
  - Daptomycin + Aztreonam
  - Vancomycin and Ceftrazidime + Metronidazole

Endorsed:
Mild Infections

➢ Begin with an oral agent with a relatively narrow spectrum covering aerobic gram(+)cocci

➢ Anaerobic organisms are infrequent in the majority of mild infections

➢ There is little data to support the use of topical antimicrobial agents and you should never use an agent that may later be used as an IV medication i.e. Gentamycin

Antibiotics Options:
Increasing order of Broad Spectrum Coverage

- Dicloxacillin
- Clindamycin
- Cephalexin
- Trimethoprim-sulfamethoxazole
- Amoxicillin/clavulanate
- Levofloxacin
Moderate Infections

Oral or parenteral based on clinical presentation

- TMP-SMX
- Amoxicillin/clavulanate
- Levofloxacin
- Cefoxitin
- Ceftriaxone
- Ampicillin/sulbactam
- Linezolid ± Aztreonam
- Daptomycin ± Aztreonam
- Ertapenem
- Cefuroxime ± Metronidazole
- Ticarcillin/clavulanate
- Piperacillin/tazobactam
- Levofloxacin or Ciprofloxacin with Clindamycin

Endorsed:

American Professional Wound Care Association (APWCA)
Severe Infections
Parenteral only

➢ Piperacillin/tazobactam
➢ Levofloxacin or Ciprofloxacin with Clindamycin
➢ Imipenem-cilastatin
➢ Vancomycin and Ceftrazidime + Metronidazole
Puncture Wounds

- Classical Presentation: Nail puncture through sole of shoe plantarly
- Most likely organism found: *Pseudomonas Aeruginosa*
- Treatment Protocol:
  - Tetanus Prophylaxis
  - Local debridement with foreign body removal
  - 1-2% likelihood of Osteomyelitis from Plantar puncture wounds
  - Antibiotic used IF clinically indicated: CIPROFLOXACIN

Endorsed:

[Logo of APWCA]
Need for Surgery

➢ Life and Limb-threatening infections
  • Necrotizing fasciitis
  • Gas gangrene
  • Extensive soft tissue loss
  • Compartment syndrome
  • Critical limb ischemia

➢ Unexplained persistent foot pain

➢ Deep space infection or deep abscess

➢ Progressive infection in the presence of appropriate medical care

Endorsed:
REACTIVE SURGERY

➢ Surgery performed in response to acute infection or non-reversible ischemia
➢ Emergent, less than optimal conditions
  • Incision and drainage
  • Debridement of necrotic tissue or infected bone
  • Partial foot amputation
  • Foot amputation
  • Trans-tibial amputation
  • Below or Above Knee amputation
    • BKA or AKA

Photo courtesy of John Steinberg DPM

Endorsed:

American Professional Wound Care Association

John Steinberg DPM
REFERENCES


*IDSA and the International Working Group on the Diabetic Foot (IWGDF) 2004*
Sample Questions: Show what you know!

All wounds that appear infected should be initially treated empirically with an Antibiotic regimen?

- True
- False

What ancillary test in your arsenal would best determine infection of a wound with the most reliability for treatment?

A) MRI
B) Culture Swab
C) Biopsy (Bone/Tissue)
D) Gram Stain
Sample Questions:

All wounds that appear infected should be initially treated empirically with an Antibiotic regimen?

- True
- False

What ancillary test in your arsenal would BEST determine infection of a wound with the most reliability for treatment?

A) MRI
B) Culture Swab
C) Biopsy (Bone/Tissue)
D) Gram Stain
Thank You & Good Luck!!

Read the questions slowly and carefully!!