

Infection

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The Comprehensive Wound Care Review Course

Endorsed :



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



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 :

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

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

Endorsed :

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 • 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 aer
- Citrobacter sp. Salmonella sp.
- Enterobacter sp. Serratia sp.
- Escherichia coli Shigella sp.
- Haemophilus influenzae
- Klebsiella sp. Stenotrophomonas
- Moraxellae catarrhalis maltophilia
- Morganella sp. Yersinia enterocolitica
- Neisseria gonorrhoea
- Neisseria meningitidis
- Proteus mirabilis
- Proteus vulgaris

Endorsed :

Aerobic vs Anaerobic Bacteria

ANAEROBES

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

AEROBES

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

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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)

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Common Bacterial Pathogens in Wounds

➤ Cellulitis:

- Staphylococcus aureus
- Streptococcus
 - Groups A, C, G

➤ Necrotizing Fasciitis

- Streptococcus
 - Groups A,G

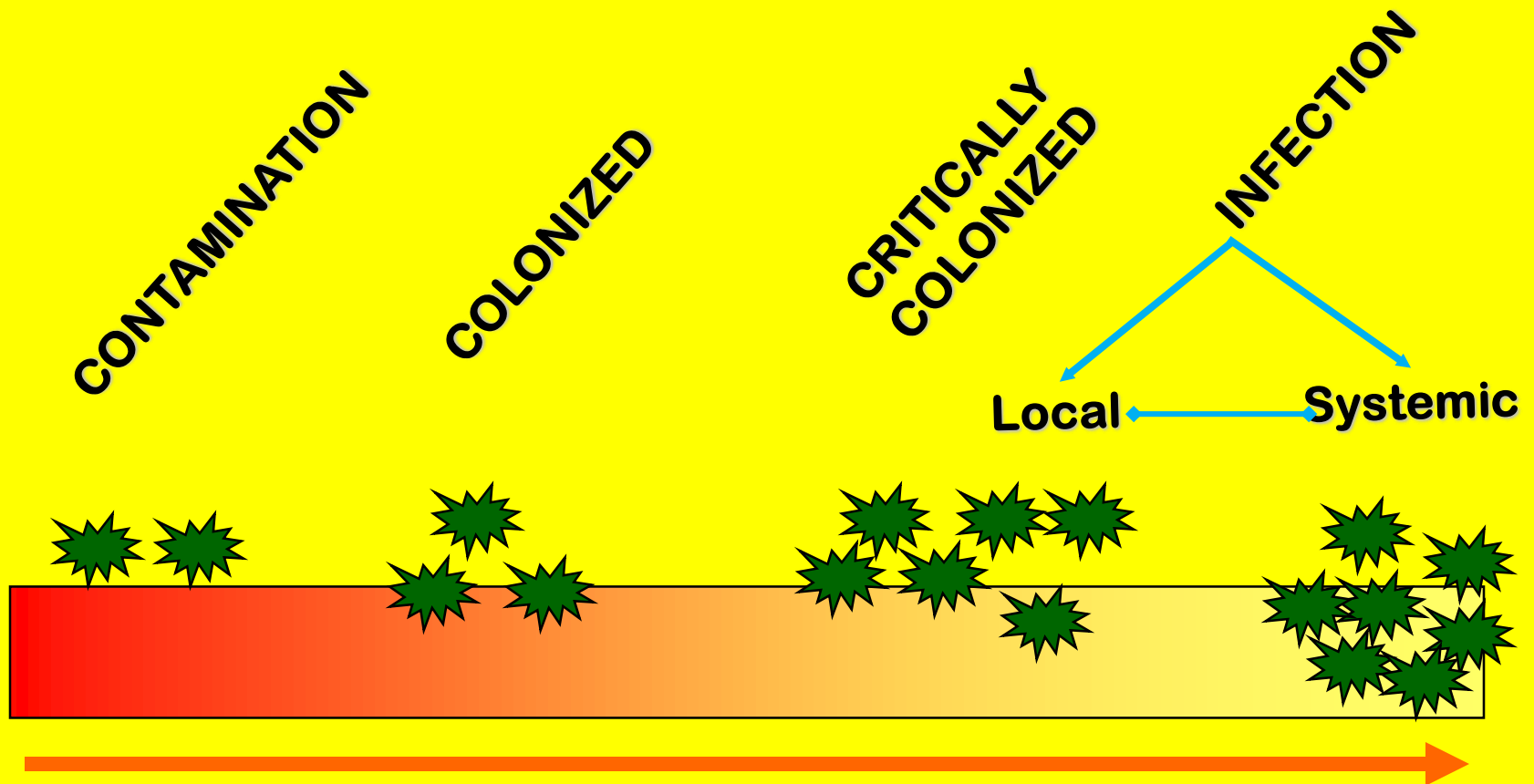
➤ Burns:

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

Endorsed :

Bacterial Burden

Contamination - Infection Continuum



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.
 - (i.e. Most organisms in the soil won't grow in a wound).

Endorsed :

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..

Endorsed :

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,

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From Colonization to Infection?

- Many factors affect the progress of microorganisms in a wound from colonization to infection:
- Infection or Presence of Disease= dose + virulence
host resistance
- The number of organisms/bacteria (dose)
- The virulence factors they produce.
- The resistance of the host to infection.

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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. agalatae*) and *Staphylococcus aureus*.

Endorsed :

Bacteria: Planktonic and Biofilms

➤ 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

Endorsed :

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*

Endorsed :

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

Local Factors

- Large wound area
- Increased wound depth
- Degree of chronicity
- Anatomic location (distal extremity, perineal)
- Foreign body
- Necrotic tissue
- Mechanism of injury (bites, perforated viscus)
- Reduced perfusion

Systemic Factors

- Vascular disease
- Diabetes
- Edema
- Malnutrition
- Alcoholism
- Prior surgery or radiation
- Corticosteroids
- Inherited neutrophil defects

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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 :

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 :

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, Enterobacteriaceae,
 - Non-fermentative gram (–) rods and
 - Obligate anaerobes
- Cellulitis *without* and open skin wound
 - B-hemolytic strep
 - Staph aureus

Endorsed :

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

Endorsed :

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

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 :

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

Endorsed :

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

Endorsed :

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

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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 \pm Aztreonam
- Daptomycin \pm Aztreonam
- Ertapenem
- Cefuroxime \pm Metronidazole
- Ticarcillin/clavulanate
- Piperacillin/tazobactam
- Levofloxacin or Ciprofloxacin with Clindamycin

Endorsed :

Severe Infections

Parenteral only

- Piperacillin/tazobactam
- Levofloxacin or Ciprofloxacin with Clindamycin
- Imipenem-cilastatin
- Vancomycin and Ceftrazidime ± Metronidazole

Endorsed :

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 :

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 :

REFERENCES

Lipsky BA, et al, *Diagnosis and Treatment of Diabetic Foot Infections. Guidelines for Diabetic Foot Infections*, CID 2004:39, October. Pp 885-910

IDSA and the International Working Group on the Diabetic Foot (IWGDF) 2004

Endorsed :



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

Endorsed:

Thank You & Good Luck!!

Read the questions slowly and carefully!!