Preventing and Managing Wound Infections

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Faculty Disclosures

I have the following relevant financial relationship with a commercial interest:

I am employed as the Clinical Research, Education, and Charity Liaison for Ferris Mfg. Corp. (makers of PolyMem® dressings)

I am also an Independent Researcher improving health in developing countries

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Educational Objectives:

Upon completion of this learning activity, participants should be able to:

1. Distinguish between high bioburden, inflammation, and infection.
2. Identify at least one wound management protocol that recent research shows actually increases the risk of infection
3. Summarize current best practices for wound management protocols

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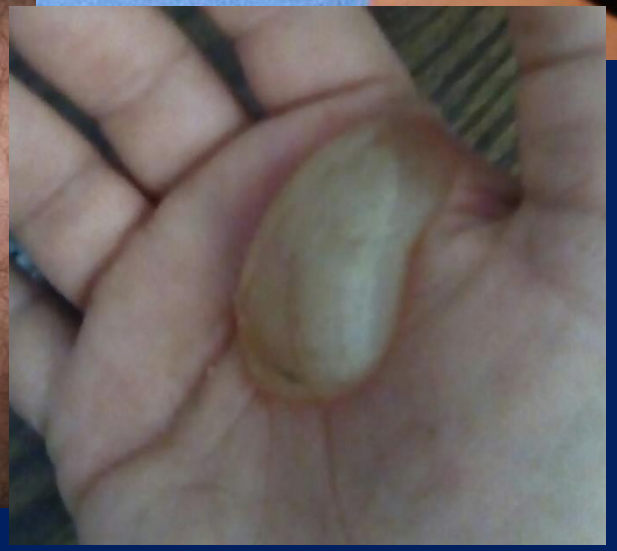
Acute Wounds Are Problems Everywhere



[1,2]

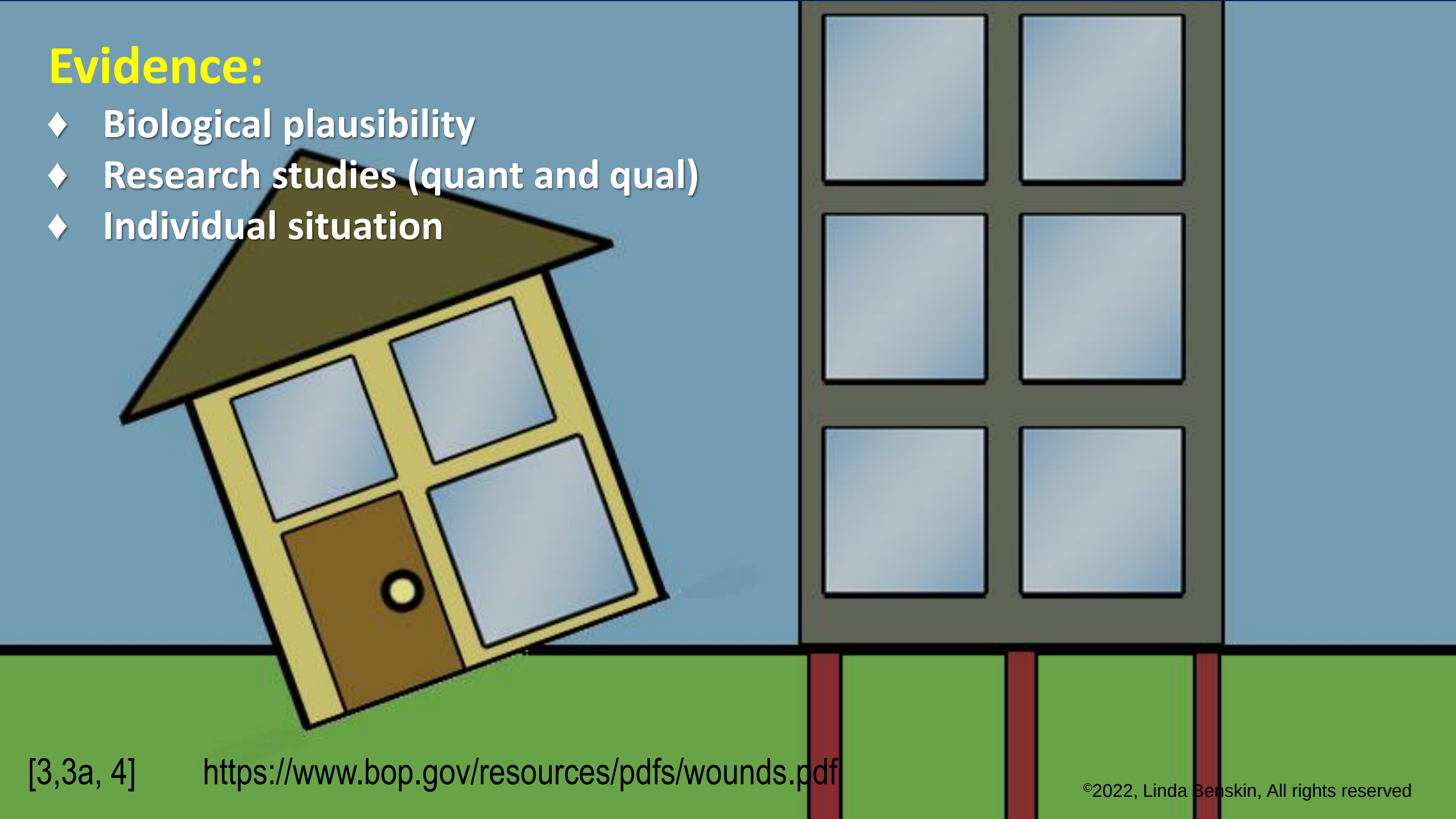
Wounds Due to Chronic Illnesses

[101, 102]

Aftermath of GSWs and Fights

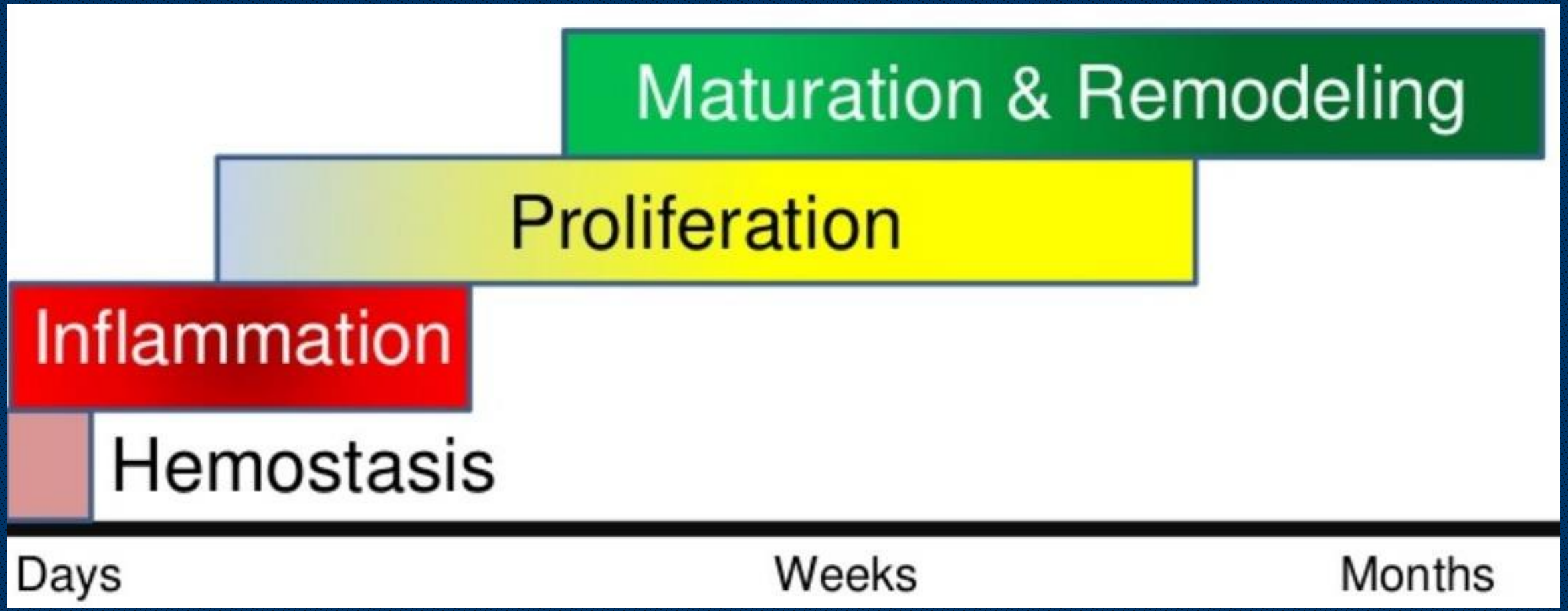
Evidence:

- Biological plausibility
- Research studies (quant and qual)
- Individual situation



[3,3a, 4] https://www.bop.gov/resources/pdfs/wounds.pdf

Stages of Wound Healing



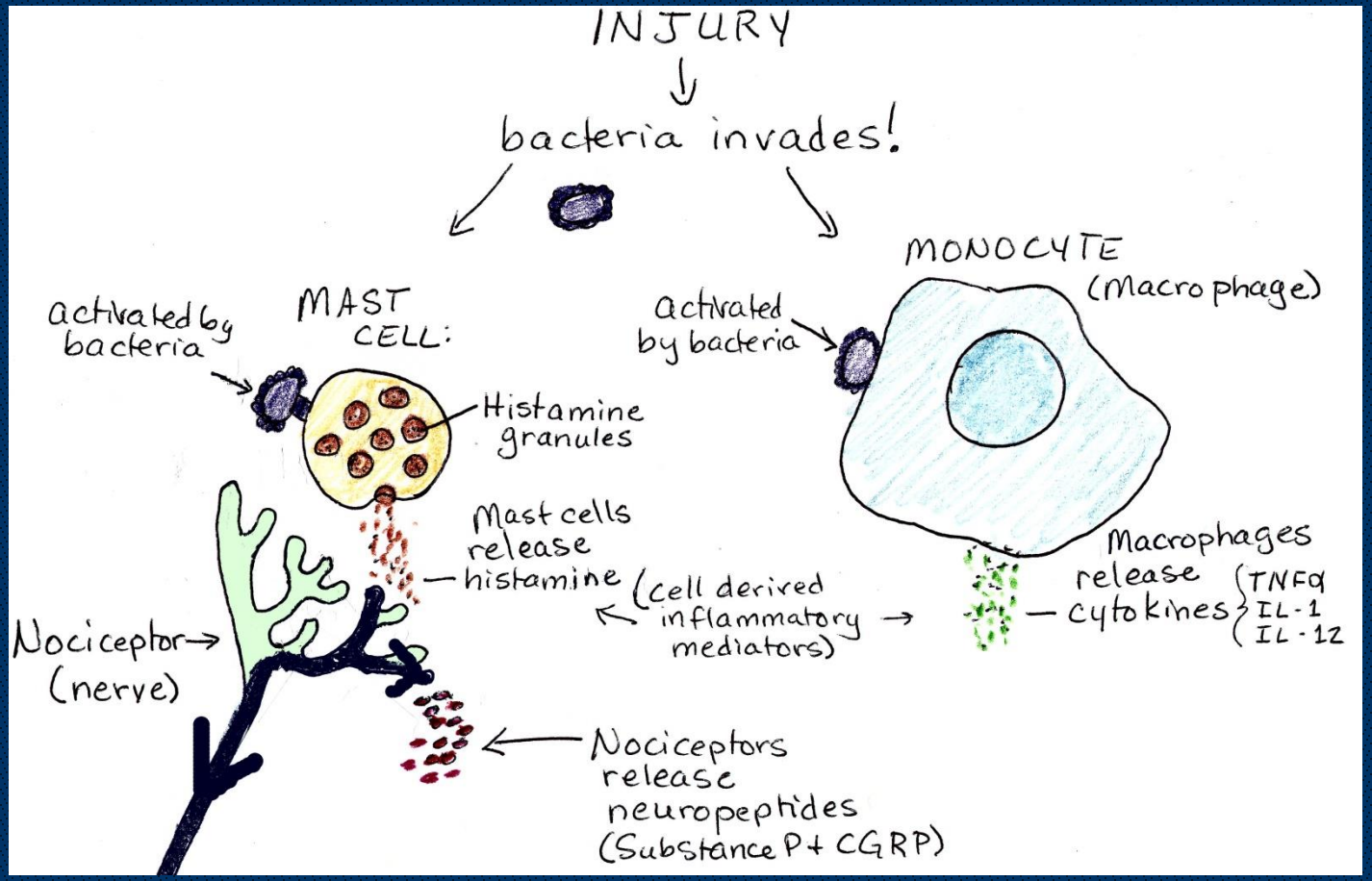
[3]

Stages of Wound Healing: Hemostasis

- Stop bleeding!
- Communication cells (cytokines) recruit
- Preparation for cleanup

[3]

Stages of Wound Healing: Inflammation



Goal: Prevent sepsis by:

- ♦ walling off area
- ♦ cleaning wound

Damaged cells release chemicals→inflammation

Central nervous system enhances inflammation

[3]

Stages of Wound Healing: Inflammation

Pain, heat, redness, swelling, increased exudate, immobility

(even without infection!)

White blood cells:

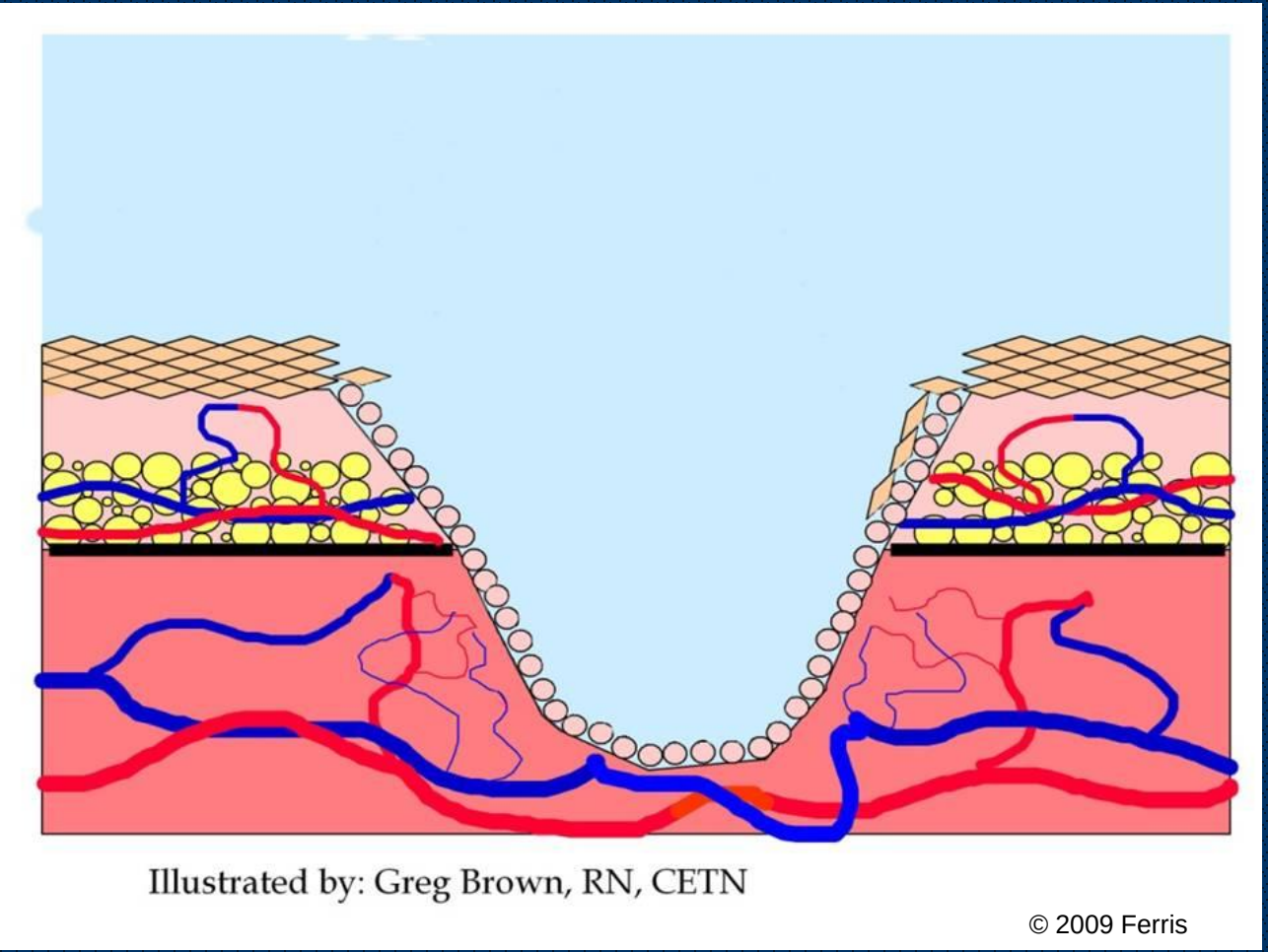
- Recycle debris
- Search and destroy bacteria
- Recruit growth factors
- Recruit cytokines

[3]

Stages of Wound Healing: Proliferation

- Fibroblasts migrate
- Angiogenesis
- Contraction
- Granulation
- Epithelialization

youtube.com/watch?v=Z8Zj6n_iH3Q



[3,5]

Moist Wound Healing

- Autolytic debridement cleans wounds
- Neutrophils migrate best with ideal moisture (no dead space)
- The complement system functions best under occlusion
- Semi-occlusive dressings promote angiogenesis (hypoxia at the surface)
- Moist dressings promote the release of growth factors (doubles healing rates)
- Occlusion decreases pain (pain increases infection risk)

[6a&b, 8, 17, 41-45, 69]

Stages of Wound Healing: Proliferation

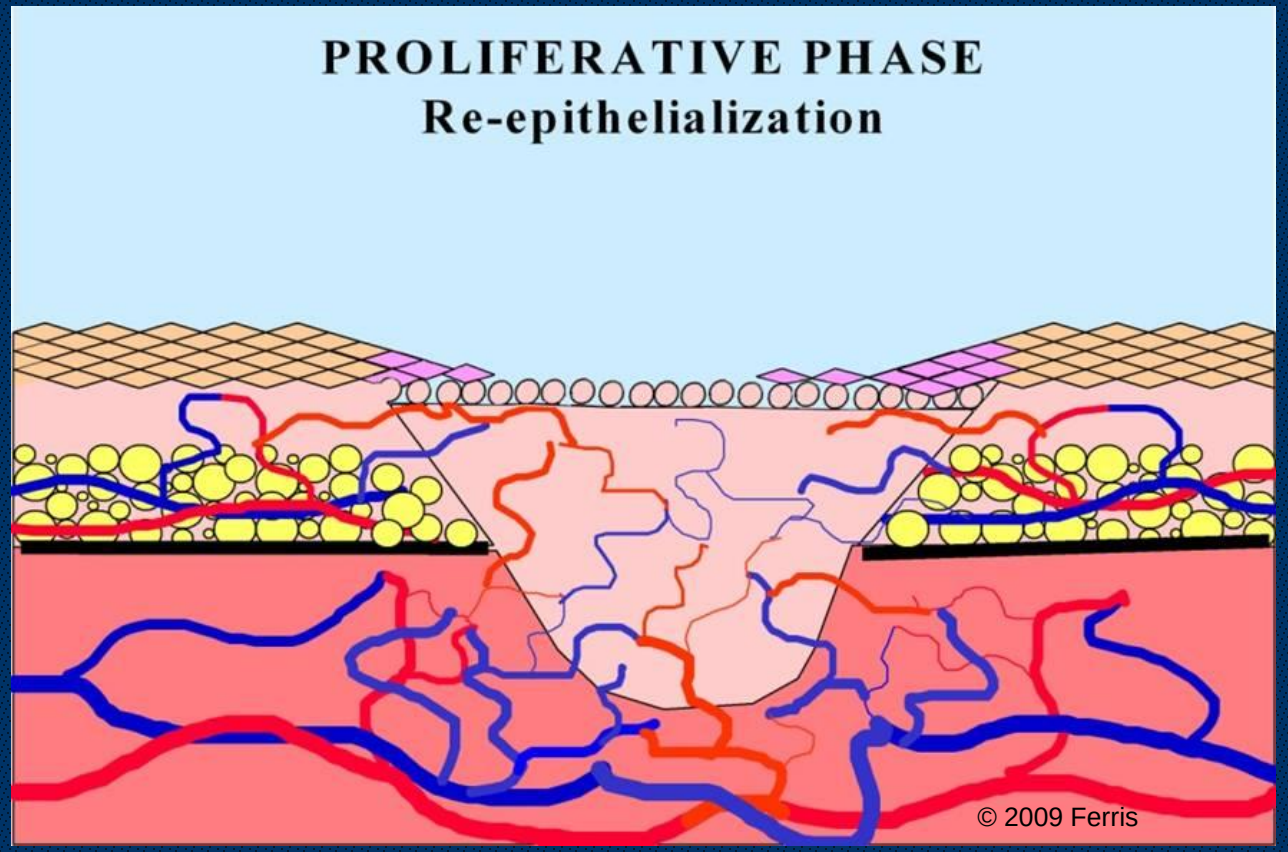
Requirements:

- Appropriate moisture
- Nourishment
- Enzymes & growth factors
- Adequate warmth
- Open Edges

Keeping the wound in the Proliferation Stage

Need to **not** have:

- Dirt or debris
- Infection
- Desiccation (drying)
- Pressure/Repeat injury
- Poor perfusion/nutrition
- Maceration
- Cooling



Stages of Wound Healing: Maturation (Remodeling)

"Closed"

- Enzymes
- Collagen → strength
- Smoother, flatter
- Final scar

Uncontrolled Inflammation → Chronic Wounds

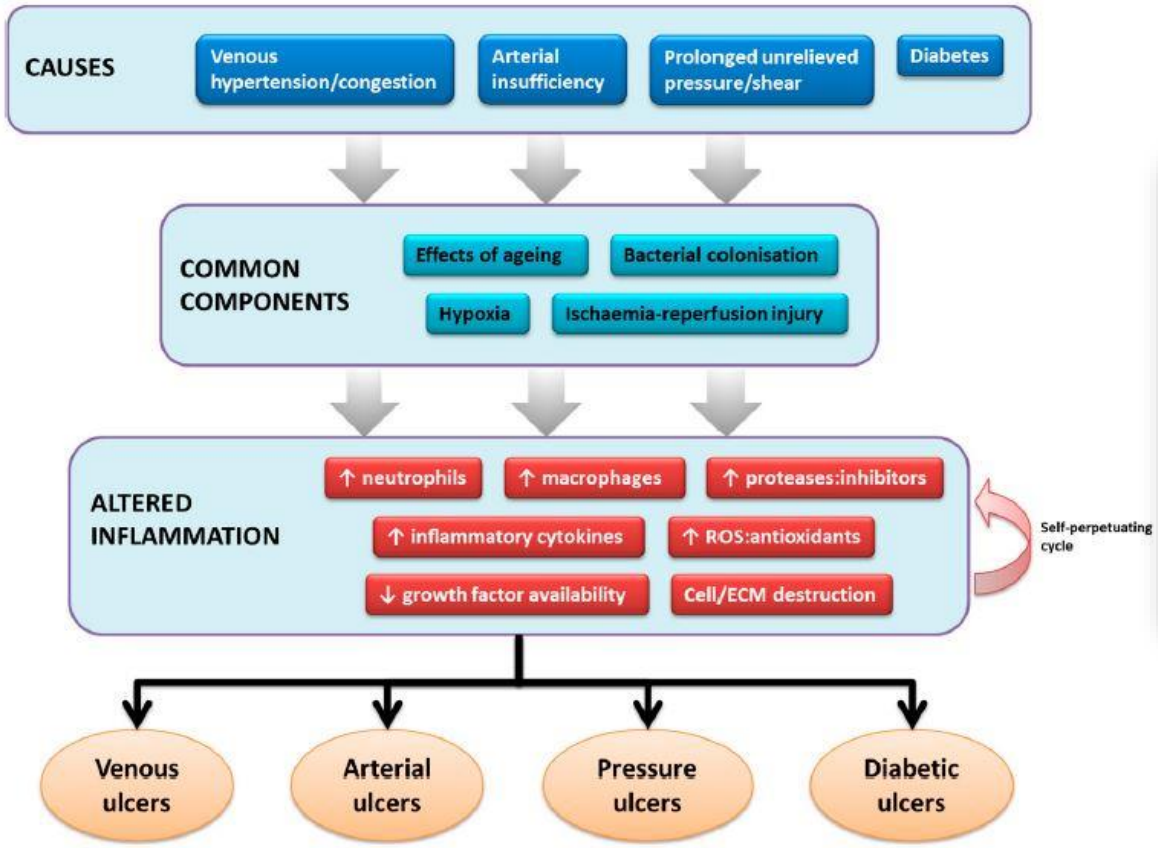
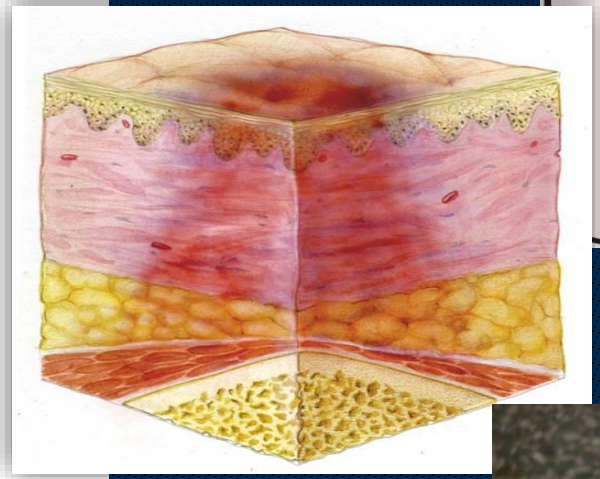
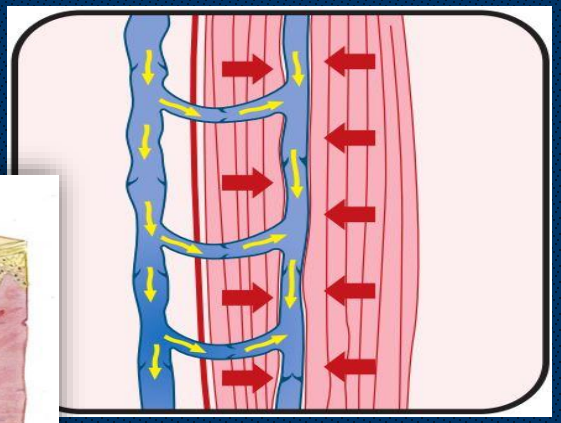


Figure 1. The role of inflammation in the pathophysiology of common chronic wounds. ROS = reactive oxygen species, ECM = extracellular matrix.





[70, 89]

Figures from [70], NPUAP, and Benskin

Objective 1:

Distinguish between:

- ♦ High bioburden
- ♦ Inflammation, and
- ♦ Infection

[6a, 6b, 7]

High Bioburden ≠ Infection!

- Bacteria in large numbers (>10^5, even >10^7) don't always slow healing (7,9,10,11,71)
- What are the bacteria doing? Invasive? Commensal? Synergistic? (6a,6b,7,8)
- Highly virulent bacteria (e.g., Strep) in moderate numbers (>10^3) (7,14)
- More than four species in high numbers – marker for slow healing (7)
- Quantitative swabs (Levine Method) OR biopsies *when symptomatic* (3, 13, 14)
- Biofilms & artificial conditions make culturing wounds unreliable (10, 12)

"The germ is nothing. It is the terrain in which it is found…" – Pasteur, 1860 (12)

Infection is a ***clinical*** diagnosis

[3, 6a-14, 71, 96, 97]

Inflammation ≠ Infection!

- Inflammation: Redness, heat, edema, pain, loss of function
- Moderate inflammation is adaptive: cleans, protects, recruits
- Excess inflammation (edema, pain) predisposes to infection
- Slough and callus are results of inflammation, not infection
- Inflammation is blunted in immunosuppressed patients

Slough, indicating inflammation, not necessarily infection ⟶

[12a&b, 14, 15]

Infection = Micro-organisms Overwhelming Host

Increasing, not diminishing, inflammation, and/or (any of these):

- Darker exudate
- Thicker exudate
- Strong or foul odor
- Slowed or stalled healing
- Lymphangitis, lymphadenopathy
- Increasing wound size
- Crepitus

Like a stagnant pond

Photo by Colin Smith (Creative Commons)

[14-17]

Kill or wipe away all the microbes?

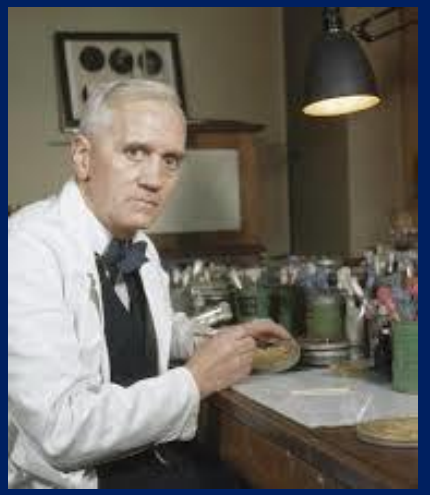


Photo TR1468, Imperial War Museum

- Alexander Fleming, in vivo & in vitro in WW1
- Rodeheaver and many others in the 1970s - 80s
- The FLOW Investigators, open fractures in 2015

All led to the exact same findings:

Antiseptics ***increased***
wound infections because they

1) kill human tissue
2) disable the immune cells

[4, 18, 28, 39]

Photo from Wiki Commons

Balance the Ecosystem

"…the medical conservative stands in awe of the human body."

– Mandrola, et al. 2019

WE (health care professionals)

DO NOT HEAL WOUNDS.
EVER.

Only the patient's own body can heal the wound.

We remove barriers and provide supports.

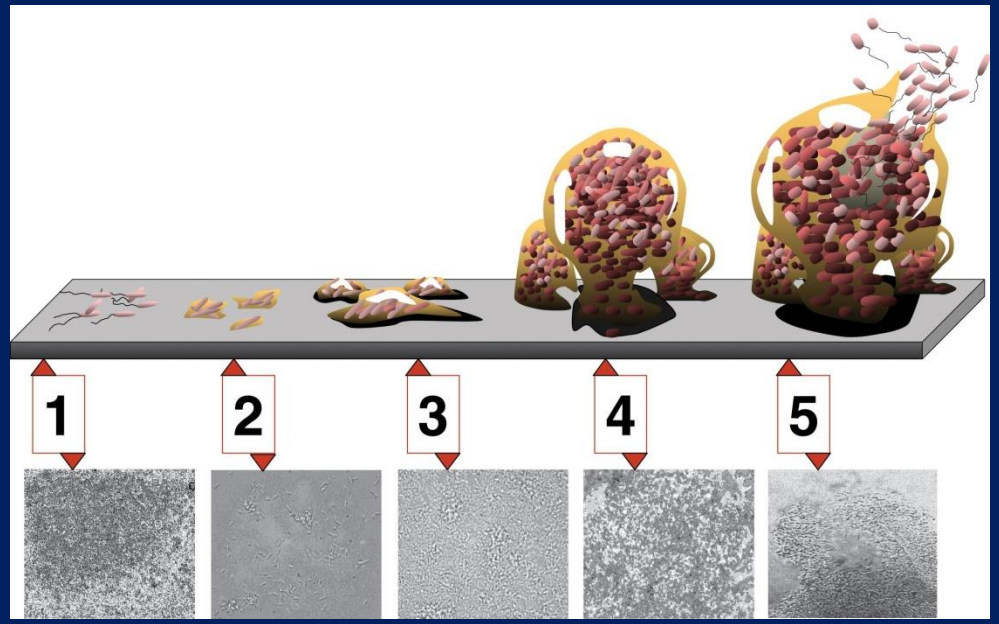
Don't kill the HUMAN.

[12, 72-76, 86]

Photo by Aleš Tošovský (Creative Commons)

What about Biofilms?

Biofilms behave completely differently when the host's phagocytes are present



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Impressive growth: "mushroom-shaped" *P. aeruginosa* biofilm on a petri dish

[4, 77-80, 86]

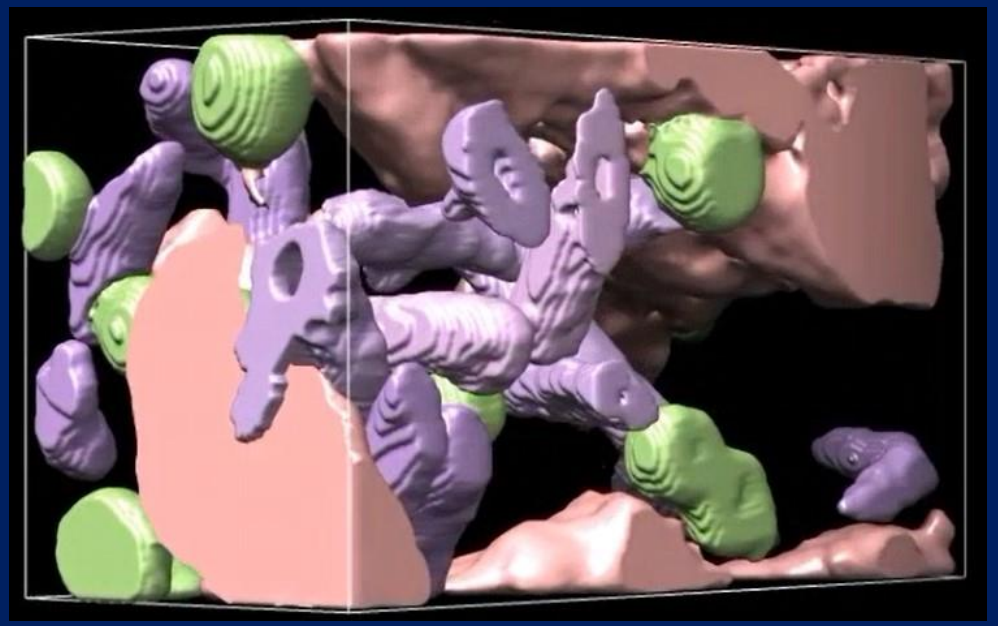


Image from Dr. Chandan Sen, used with permission

Phagocytes destroying a mature biofilm (*P. aeruginosa* and *A. baumannii*)

Objective 2

Identify at least one
wound management protocol
that recent research shows
actually increases
the risk of infection

Practices that Increase Infection Risk

1. Using antiseptics in open wounds. (Almost) Ever.
   - ♦Cannot kill every microbe
   - ♦Are quickly deactivated
   - ♦Creates a layer of dead tissue
   - ♦Impairs leukocyte function
   - ♦Increases infection rates vs saline

   Hypochlorous acid and/or conventional silver? Also toxic!

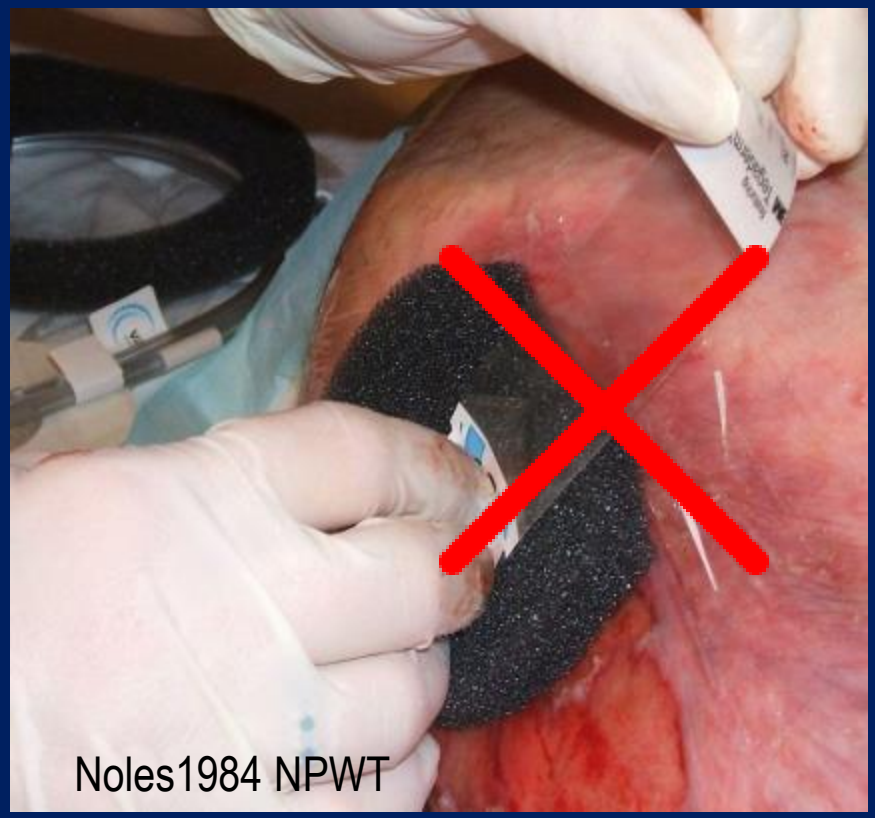
Note: This is NOT an open wound ⟶

This IS⟶

[3, 4, 18-28, 58, 67, 73, 84, 85]

Practices that Increase Infection Risk

2. Using conventional negative pressure wound therapy (NPWT)
   - ♦ Compared with what?
     Saline-soaked gauze!!!
   - ♦ Pain, cortisol, stress response
   - ♦ Dramatic protein losses (WBCs?)
   - ♦ Reviews of studies show
     - ♦ Increased infection rates
     - ♦ Increase in costs
     - ♦ Decrease in quality of life
     - ♦ No increase in healing rates



[29 - 36]

Practices that Increase Infection Risk

3. Using *high pressure* irrigation on wounds (> 15 psi)

- *Appears* to effectively debride
- Drives microbes into tissue
  (increases deep infection rate)
- Damages bone, delays healing
- Overall, infection rates are higher

Trust the patient's body!

Do NOT use high pressure!

[15, 28, 37, 38]

Practices that Increase Infection Risk

4. ALL forms of mechanical debridement (wet-to-dry, whirlpool, *Scrubbing* the wound bed, even with a soft sponge)

- Wounds appear cleaner, however,
- Tears cell membranes; bacteria enter
- Pushes microbes deeper into crevices
- Pain leads to stress response
- Higher infection rates with scrubbing (All mechanical debridement)

Serial (e.g., weekly) sharp debridement???

Also NO improvement in healing

[3, 4, 15, 39, 40, 56]

Practices that Increase Infection Risk

5. Using non-occlusive dressings or “open to air”

- Bacteria can easily penetrate many layers of gauze
- Infection rates are > twice as high with dry wounds
- Cells die in dry wound beds (necrotic tissue leads to infection)
- Wet-to-dry is especially traumatic – soak if adhered

[17, 56, 87, 88]

6. Failure to Address Edema

- Edema is a major precipitator of soft tissue infection – pooled fluid
- Edema leads to circulatory compromise → hampers the immune response
- Edema impairs cell migration from wound edges, slowing wound closure
- Edema is a sign of inflammation – try to address the cause (venous disease?)

(***How*** to control edema is in the best practices section)

[3, 89, 90]

Objective 3

Summarize
current best practices
for
wound management
protocols

What *should* we do instead?

1. Low pressure irrigation with *copious* quantities of:
   - ♦ Saline (unless pseudomonas)
   - ♦ Drinkable water, or
   - ♦ A nontoxic *nonionic* surfactant
   - ♦ Body temperature
   - ♦ Goal is 4 – 15 psi, turbulent flow
   - ♦ May require 3 liters+ for major trauma
   - ♦ Irrigate before and after initial sharp debridement

Preferred irrigation technique

No need to kill the microbes – just remove them

[4, 18, 21, 28, 39, 104, 105, 106]

Initial Sharp Debridement (NOT serial sharp debridement)

2. Initial sharp debridement – spare all viable skin & tissue

- Sharp steel ⟶ fewer infections than tearing
  - Cut just enough to allow irrigation in all cavities
  - Remove clearly nonviable tissue (some will rehydrate)
  - Trust autolytic debridement to complete the task
- Sharp debridement is *essential* for closed abscesses

[21, 22, 78, 79]

Best Practices for Reducing Infections

3. Use moisture-retentive, conforming dressings
   - ♦Decreases overall infection rates: >100 human studies by 1990
   - ♦Maintains a moist warm wound environment for new cells to grow
   - ♦Supports autolytic debridement
   - ♦Seals completely against pathogens
   - ♦Decreases pain (which ↓s stress response)
     - ♦Occlusion alone decreases pain
     - ♦PMDs directly alter the nociceptor response
   - ♦Increases healing rates (no wound, no wound infection)

[3, 6, 8, 15, 17, 19, 42-44, 46, 47, 89]

Best Practices for Reducing Infections

4. Address Edema (↑ lymphatic drainage & circulation)

- Compression and elevation for extremity wounds (walking is 2nd best)
- NPWT with saline instillation – promising in high drainage wounds? Maybe…
  - NO antiseptics!!!
- Polymeric membrane dressings
  - Gently pull fluid from the body into the wound bed (3mm Hg pressure)
  - Subdue, focus inflammation
  - Dramatic decrease in swelling
- Honey dressings
  - Mild osmotic pull

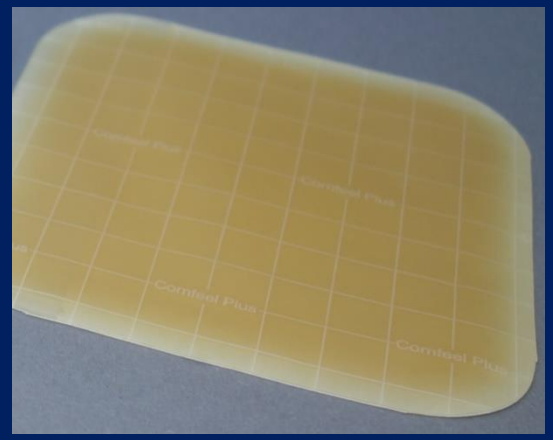
Photo from James Heilman, MD WikiCommons

[3, 12, 30, 32, 47-54, 89, 90]

Best Practices for Reducing Infections

5. Use dressings which fight infection while in place

- Polymeric membrane dressings: cleanse
- Bacteria binding dressings (???)
- Hydrocolloids: low pH
- Honey-containing dressings: low pH



- Moisture promotes autolytic debridement – even plastic wrap or petrolatum
- Dressings with locked-in antimicrobials

[46-48, 53-57, 81]

Does autolytic debridement really work?

Tropical environment, VERY basic dressings: THREE DAYS

Evening: 22 Dec

Morning: 23 Dec

Evening 25 Dec

[46-48]

What about immunosuppressed patients?

Initial, before and after debridement

Diabetes (or Hepatitis, HIV+, Chemotherapy)?

Outcomes (and guidelines) are unchanged: sharp debridement, then moist dressings.

(HIV+ on ART: CD4 > 100; Others, ANC > 100 - 500)
Watch for fungal infections

6.5 wks of moist, non-toxic treatment (closed at 8 wks) (no offloading available)

[91-95]

Best Practices for Reducing Infections

6. Sparing (limited) Use of Antimicrobials

- Antimicrobial dressings **are** useful in limited circumstances
  - Limit to 2 weeks for critical colonization, local, or deep wound infection
  - Use only dressings with **locked-in** antimicrobial (less toxicity)
- Antibiotic or antiseptic ointments? Sensitization, resistance…
  - Dilute antimicrobial wash if circulation is severely compromised (scars)
  - In truly immunosuppressed patients, with recalcitrant biofilms
- Add systemic antibiotics for **deep tissue** infections
  - Cellulitis, Osteomyelitis, Sepsis – evidence-based recommendations next slide
  - Highly virulent microbes: Strep A and Strep pyogenes

[19, 26, 59-61, 97]

Managing Deep Tissue Infections: CDC.gov

Oral antibiotics often as effective as IV

Older antibiotics often as effective as newer

- ♦ No antibiotics for simple abscesses – just drain and irrigate well
- ♦ Osteomyelitis: either flucloxacillin and sodium fusidate, or ciprofloxacin and clindamycin, for 5 weeks
- ♦ Bites (human or animal): amoxicillin/clavulanate for 5 – 10 days
- ♦ CA-MRSA: oral TMP/SMX, clindamycin, linezolid, or teicoplanin, or a tetracycline; or IV vancomycin
- ♦ Beta-hemolytic strep (with coverage for possible CA-MRSA): clindamycin or linezolid alone; or TMP/SMX or a tetracycline (doxycycline or minocycline) plus amoxicillin

(NOTE: Teicoplanin and polymyxin B neutralize endotoxins)

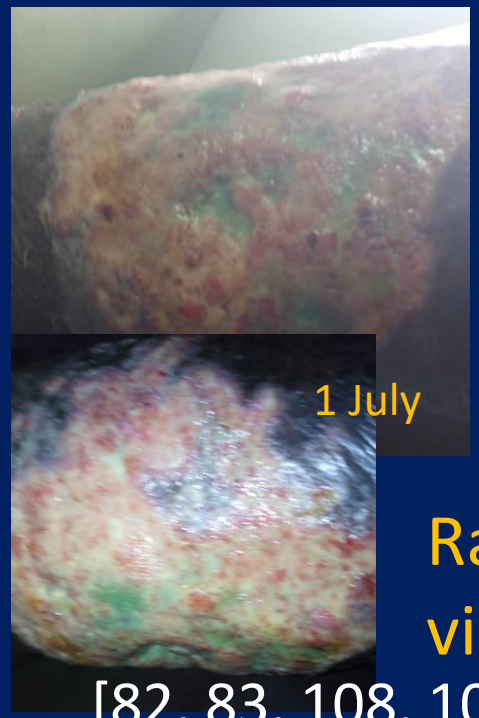
Triple-strength saline soaks BID to eradicate fungal infections

[4, 96-100, 107]

Pseudomonas A. in Chronic Wounds

If pseudomonas is overwhelming the host: 1% white vinegar

- pseudomonas prefers slightly salty environment (saline rinses)
- pseudomonas does not tolerate acidic environment (vinegar restores low pH)
- Twice daily until green (and distinctive odor) is gone for two days



Rarely, a pseudomonas biofilm is best addressed with dilute white vinegar (acetic acid diluted in water 5:1) – BID for 3 – 5 days

[82, 83, 108, 109]

Recurrent MRSA Infections

MRSA acquired in a jail, many admissions for IV antibiotics before PMDs

Community-acquired MRSA, recurrent. Oral antibiotics, no surgical intervention. Two elbow wounds. Began using PMD rope. Third (cheek) was last.

Officer in juvenile detention with recurrent MRSA ulcers requiring I&D and packing. Debilitating pain with conventional packing of leg MRSA ulcer. NO pain with PMDs. PMD rope led to quick resolution of cheek MRSA ulcer.

First Aid to Prevent Wound Infections

Goal is to prevent more DAMAGE

- Stop bleeding: direct pressure, wide tourniquet - only if needed
- Irrigate with tap water to cool and clean
  - For burns, cool water at LEAST **20 min**
  - Other wounds, body temperature
  - Low pressure, high volume (until clear)
- Dress to maintain moisture & warmth
  - Plastic food wrap (clean, nonadherent)
  - Can improvise with inside of clean plastic bag
- Immobilize/Splint if needed
- Compress/elevate if trip to facility is long

[47, 57, 62, 68]

By Jenny Downing (glass half-full) via Wikimedia Commons

Initial Wound Management: Surgical Preps

- Presurgical showering: soap & water?
- Clean off visible dirt first
- No shaving hair: Clip
- Scrub (don't just paint) sites three times
- Use at least two different solutions
- Saline performed as well as antiseptics
- Allow povidone-iodine time to dry
- Use at recommended concentrations
- Final scrub solution can remain (esp if saline)

[63-66]









[96]

Summary

For ALL wounds:

- Very conservative initial sharp debridement – if feasible
- Irrigate with NON-TOXIC fluids at low pressure
- Copious irrigation until the resultant fluid runs clear
- Dress for success: use a conforming dressing that retains moisture
- Address edema (compression, certain dressings, elevation, …)
- Add systemic antibiotics IFF there are signs of deep infection
- Trust the patient's body to heal the wound

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