Wound Infection Day

Supported by an educational grant from the Urgo Foundation

Faculty

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Faculty Disclosures

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Lisa Gould, MD, PhD, FACS
Consultant: Avita Medical

Terry Swanson, NP
Advisory Board: Coloplast Global; Speaker's Bureau: BBraun; Coloplast Global; Convatec; Smith and Nephew; Solventum; Urgo Medical

Disclosures

Faculty have been informed of the responsibility to disclose to the audience if they will be discussing off-label or investigational use(s) of drugs, products, and/or devices (any use not approved by the US Food and Drug Administration)

- Applicable CME staff have no relationships to disclose relating to the subject matter of this activity
- This activity has been independently reviewed for balance

This continuing medical education activity includes device or medicine brand names for participant clarity purposes only. No product promotions or recommendations should be inferred.

AGENDA

Start Time	End Time	Topic	Faculty
3:30 PM	3:40 PM	Intro and drivers of wound infection today	Michael Desvigne, MD, FACS, CWS, FACCWS
3:40 PM	3:50 PM	Determine if there are gradations of contamination that be agreed upon and differentiate modes of treatment for wounds contaminated at various levels Categorize the levels of microbes in the wound	Abigail E. Chaffin, MD, FACS, CWSP, FAPWCA
3:50 PM	4:00 PM	Assess current techniques, in the in-patient and out-patient settings, to determine levels of contamination and identify which method to use and when	Lisa Gould, MD, PhD, FACS
4:00 PM	4:10 PM	Silver, Iodine, acetic acid and systemic antibiotic in the management of infection	Lisa Gould, MD, PhD, FACS
4:10 PM	4:20 PM	Outline new and emerging technologies to determine levels of contamination and infection in the wound	Terry Swanson, NP
4:20 PM	4:30 PM	Slough removal and infection control	Terry Swanson, NP
4:30 PM	4:40 PM	Examine findings from the recent IWII cleansing guidelines	Terry Swanson, NP
4:40 PM	4:50 PM	New and emerging technologies for slough removal	Michael Desvigne, MD, FACS, CWS, FACCWS
4:50 PM	5:00 PM	BREAK	
5:00 PM	5:30 PM	Hands-On Rotating Stations	
		Vashe/ UrgoClean AG	Michael Desvigne, MD, FACS, CWS, FACCWS
		Misonix	Abigail E. Chaffin, MD, FACS, CWSP, MAPWCA
		Moleculight	Terry Swanson, NP
		Solventum	Lisa Gould, MD, PhD, FACS
5:30 PM	5:40 PM	Cases	Chaffin; Swanson; Gould; Desvigne
5:40 PM	5:45 PM	Q&A	Chaffin; Swanson; Gould; Desvigne

Learning Objectives

- Explain the drivers of wound infection today
- Determine if there are agreed upon gradations of contamination and differentiate modes of treatment for wounds contaminated at various levels; what role, if any, does biofilm have in the issues faced?
- Categorize the levels of microbes in the wound
- Assess current techniques in inpatient and outpatient settings to determine levels of contamination and identify which method to use and when
- Explain the role of silver, iodine, acetic acid, and systemic antibiotic in the management of infection
- Outline new and emerging technologies to determine levels of contamination and infection in the wound
- Determine the relationship between slough removal and infection control
- Examine findings from the recent IWII cleansing guidelines
- Examine new and emerging technologies for slough dermal removal, including a novel hypochlorous acid, charged fiber
- Explore illustrative case studies on wound infection management and apply current strategies

The Drivers of Wound Infection Today

Michael N. Desvigne, MD, FACS, CWS, FACCWS, MAPWCA
Plastic and Reconstructive Surgery, Wound Care and Hyperbaric Medicine, Abrazo Arrowhead Hospital and Wound Clinic
Glendale, AZ

Wounds and Bacteria

- All chronic wounds are contaminated by bacteria[1]
- Wound healing can occur in the presence of bacteria[2]
- Certain bacteria (*Staphylococcus aureus*) appear to aid wound healing[3]

Thus, it is not the presence of the microorganisms, but their type and numbers that determine their influence on wound healing

1. Sibbald, G et al. Increased bacterial burden and infection: NERDS and STONES. Wounds UK, 2007, Vol 3, No 2 25- 46.
2. Laato M, Niinikoski J, Lundberg C, & Gerdin B Inflammatory reaction and blood flow in experimental wounds inoculated with Staphylococcus aureus. European Surgical Research 20, 33-38 (1998).
3. Levenson SM, Kan-Gruber D, Gruber C, et al. Wound healing accelerated by Staphylococcus aureus. Archives of Surgery 118, 310-320 (1983).

Gradations of Contamination and Modes of Treatment for Various Levels

Abigail E. Chaffin, MD, FACS, CWSP, MAPWCA
Professor and Chief, Division of Plastic Surgery
Tulane University
New Orleans, LA

Wound Infection: Contamination vs Colonization

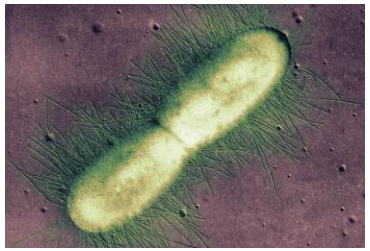
- Chronic wounds affect 20 million individuals worldwide
- Annual cost for their treatment and management is **$31 billion**

- **Wound infection** delays the wound healing rate and requires immediate treatment
- 3 stages in the wound infection continuum
  - CONTAMINATION
  - COLONIZATION
  - INFECTION

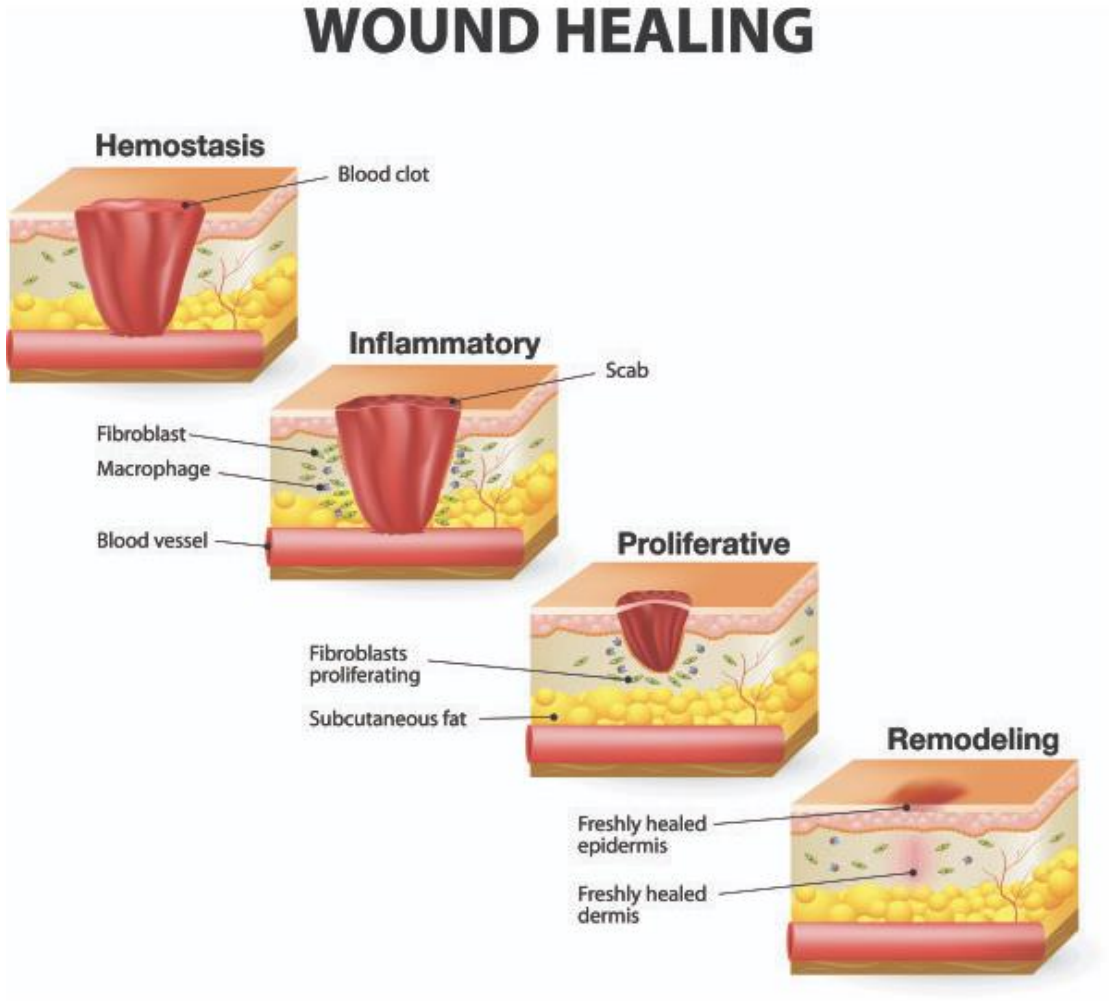
Sun H, Pulakat L, Anderson DW. *Curr Drug Targets.* 2020;21(12):1264-1275.

Wound Infection: Contamination vs Colonization

- **Wound contamination** is the presence of nonreplicating microbes in an open wound
  - The presence of small numbers of microbes does not affect normal inflammatory responses and wound healing processes
- **Microbial replication causes wound colonization**
  - Prolongs the **inflammatory phase** of wound healing and leads to further tissue damage

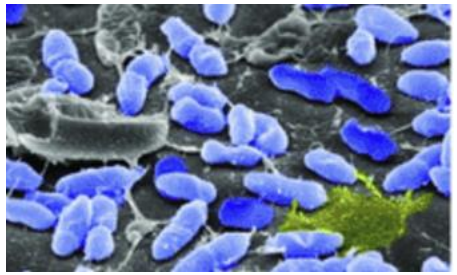


Credit: CNRI / Getty Images



Factors Influencing Microbial Load in a Wound

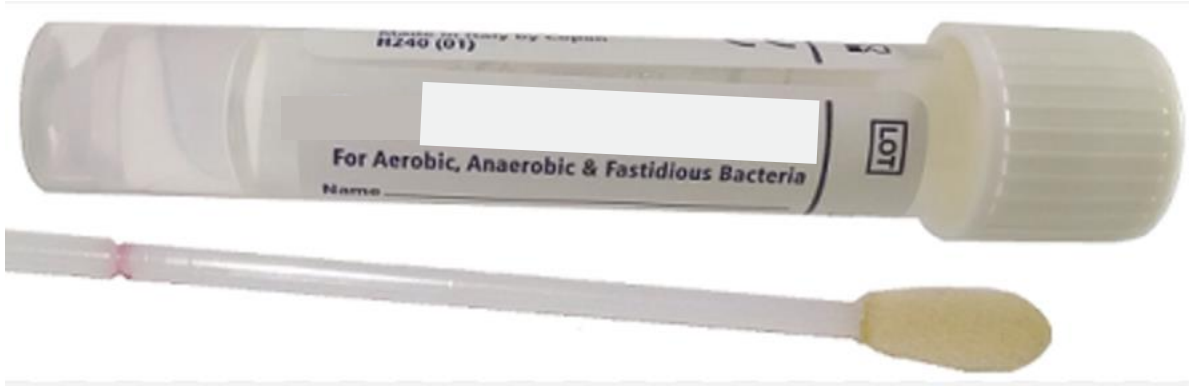
- **Wound Type**
  - The type of wound (eg, surgical, traumatic, pressure ulcer) can influence the potential for microbial contamination
- **Wound Depth and Location**
  - Deeper wounds and those in areas with higher microbial populations (eg, near the gastrointestinal tract) are at higher risk of contamination
- **Tissue Perfusion**
  - Poor blood flow to the wound can impair the body's ability to fight infection, leading to increased microbial load
- **Host Immune Response**
  - The strength of the host's immune system plays a crucial role in controlling microbial growth and preventing infection
- **Presence of Biofilms/Microbial Colonies**
  - Biofilms, which are communities of microorganisms encased in a protective matrix, can be a common finding in chronic wounds and can make infections more difficult to treat



Asghari E, Kiel A, Kaltschmidt BP, et al. Identification of Microorganisms from Several Surfaces by MALDI-TOF MS: *P. aeruginosa* Is Leading in Biofilm Formation. *Microorganisms*. 2021;9(5):992. Published 2021 May 4. doi:10.3390/microorganisms9050992

Assessing Microbial Load in a Wound

- **Clinical Examination**
  - Visual inspection of the wound for signs of infection, such as redness, swelling, pain, and pus, can help assess the level of microbial load
- **Wound Cultures**
  - Taking a sample of the wound tissue or fluid and culturing it in a laboratory can help identify the types and number of microorganisms present
- **Molecular Techniques**
  - Molecular methods, such as PCR, can be used to detect and identify microorganisms, even those that are difficult to culture
- **Quantitative Cultures**
  - These cultures measure the number of microorganisms per gram of tissue or milliliter of fluid, helping to determine if the wound is colonized or infected
- **Semiquantitative Cultures**
  - These cultures assess the growth of microorganisms on a plate, providing a relative measure of the microbial load

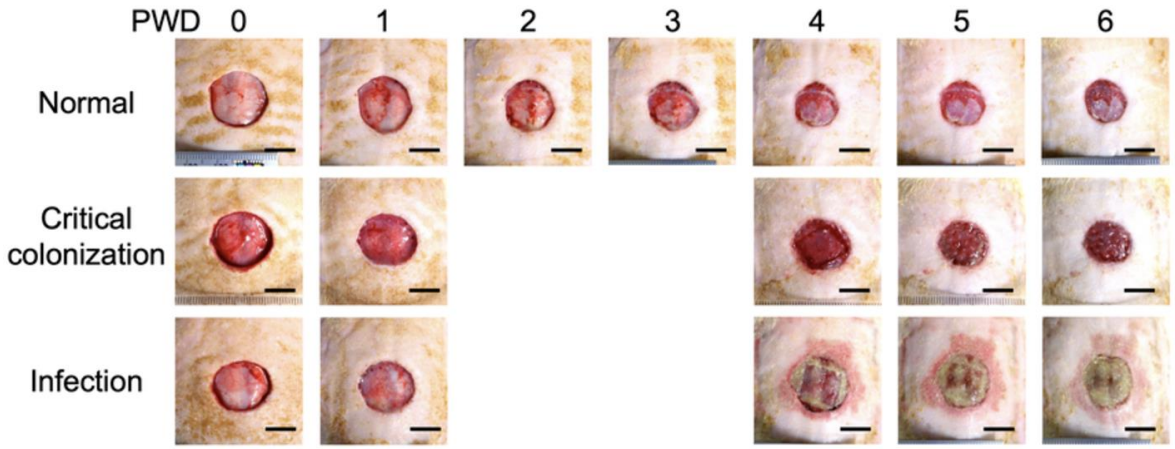


Critical Wound Colonization

- Multiplication of organisms without invasion but **interfering with wound healing**
  - Wounds often stagnate, rather than improve in condition
  - Obvious signs of infection, such as fever and inflammation, tend to be absent
  - Discoloration and odor may be observed

- Bioburden level of >105 bacteria/gm of tissue is the threshold at which critical colonization crosses into infection
- >106 bacteria/gm of tissue leads to impeded wound healing

- **TIPPING POINT** where treatment becomes necessary **TO STOP THE PROGRESSION TO INFECTION**
  - Topical antiseptics can help control the bioburden
  - Allow wound healing to proceed



6. Landis S, Ryan S, Woo KY, Sibbald G. Infections in chronic wounds. In: Krasner DL, ed. Chronic Wound Care: The Essentials—A Clinical Source Book for Healthcare Professionals. Malvern, PA: HMP Communications; 2014:87–130.

Takizawa C, Minematsu T, Nakagami G, et al. Expression levels of NPPB, ITGB6, CPNE4, EML5, and ITSN1 in fresh exudates swabbed from critically colonized and infected full-thickness wounds in rats. *Int Wound J*. 2023;20(4):1088-1097. doi:10.1111/iwj.13965

Wound Infection

Contamination	All open wounds may contain microorganisms. They will not multiply or persist until suitable nutritive and physical conditions are available for each microbial species, or they successfully evade host's defenses. Consequently, their presence is only transient and wound healing is not delayed.
Colonization	Microbial species successfully grow and divide, but do not cause damage to the host or initiate wound infection.
Local infection	Covert (subtle) signs of local infection: Hypergranulation (excessive "vascular tissue"); bleeding, friable granulation; epithelial bridging and pocketing in granulation tissue; wound breakdown and enlargement; delayed wound healing beyond expectations; new or increasing pain; increasing malodor. overt (classic) signs of local infection: Erythema; local warmth; swelling; purulent discharge; delayed wound healing beyond expectations; new or increasing pain; increasing malodor.
Spreading infection	Extending in duration +/− erythema; lymphangitis; crepitus; wound breakdown/dehiscence with or without satellite lesions; malaise/lethargy or nonspecific general deterioration; loss of appetite; inflammation, swelling of lymph glands.
Systemic infection	Severe sepsis; septic shock; organ failure; death.

International Wound Infection Institute (IWII) Wound infection in clinical practice. *Wounds International.* 2016.

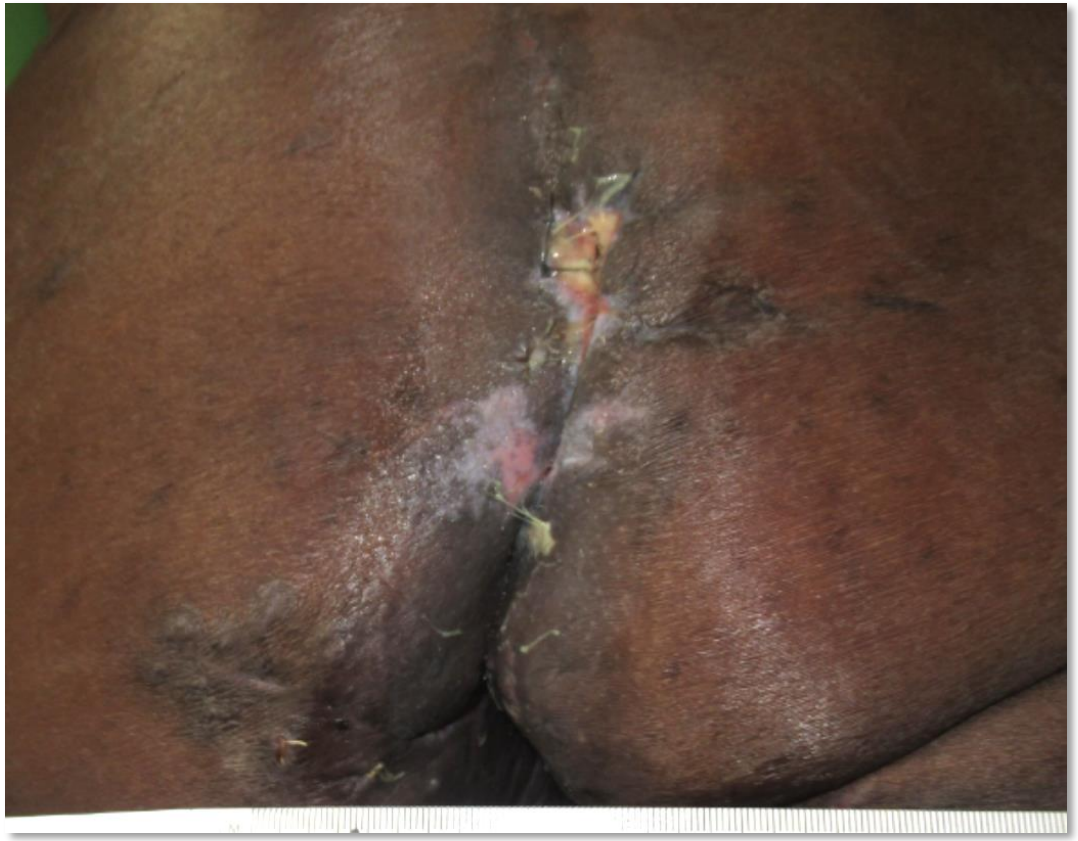
SSIs

- CDC healthcare-associated infection (HAI) prevalence survey
  - 110,800 surgical site infections (SSIs) associated with inpatient surgeries in 2015
  - 4% increase in SSI standardized infection ration (SIR) related to all National Healthcare Safety Network (NHSN) operative procedure categories combined compared to previous year

- Advances have been made in infection control practices
  - Improved operating room ventilation
  - Improved sterilization methods, barriers
  - Improvements in surgical techniques
- However, SSIs remain a substantial cause of
  - Morbidity
  - Prolonged hospitalization
  - Mortality

SSIs

- SSI accounts for **20% of all HAIs**
- SSI is associated with a **2- to 11-fold** increase in the risk of mortality
- **75% of SSI-associated deaths** are directly attributable to the SSI
- **SSI is the most costly HAI type**
  - Estimated annual cost of **$3.3 billion**
  - Extends hospital **length of stay (LOS)** by 9.7 days
  - Cost of hospitalization increased by more than **$20,000 per admission**



NHSN
NATIONAL HEALTHCARE SAFETY NETWORK

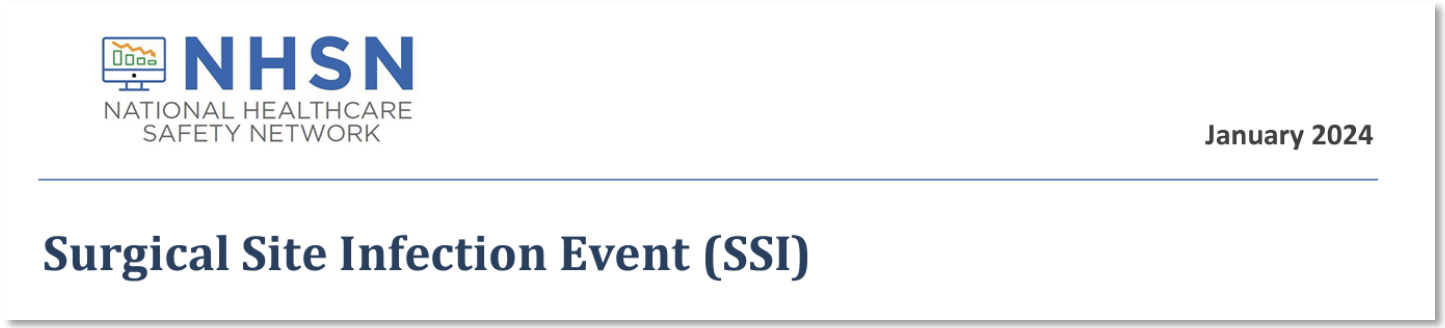
January 2024

Surgical Site Infection Event (SSI)

SSI Wound Class

- An assessment of the **degree of contamination of a surgical wound** at the time of the surgical procedure
- **Wound class** is assigned by a person involved in the surgical procedure based on the wound class schema
  - Surgeon, circulating nurse

- The 4 wound classifications available within the NHSN application are
  - **Clean (C)**
  - **Clean-Contaminated (CC)**
  - **Contaminated (CO)**
  - **Dirty/Infected (D)**



SSIs

ACS-NSQIP surgical wound classifications [11]

Clean	Uninfected operative wounds without inflammation; respiratory, alimentary, genital or uninfected urinary tracts are not entered
Clean/ Contaminated	Operative wounds in the respiratory, alimentary, genital or uninfected urinary tracts are electively entered; without unusual contamination
Contaminated	Open, fresh, accidental wounds, operations with major breaks in sterile technique or gross spillage from the gastrointestinal tract, and incisions in which acute, non-purulent inflammation is encountered
Dirty	Old traumatic wounds with retained devitalized tissue or those that involve existing clinical infection or perforated viscera

ACS-NSQIP, American College of Surgeons-the National Surgical Quality Improvement Program.

Mioton LM, et al. *Arch Plast Surg.* 2013;40(5):522-9.

SSIs

APS Archives of Plastic Surgery

Comparison of overall postoperative SSIs reported in ACS-NSQIP stratified by wound classification [13]

Population	Clean	Clean/Contaminated	Contaminated	Dirty
All specialties[a)]	2.58%	6.67%	8.61%	11.80%
Plastic surgery	2.75%	2.82%	4.94%	5.06%

ACS-NSQIP, American College of Surgeons-the National Surgical Quality Improvement Program; SSIs, surgical site infections.

Rates of overall complications, surgical site infections, reoperation, and mortality by wound classification

Postoperative outcomes	Clean (n = 12,530)	Clean/Contaminated (n = 1,098)	Contaminated (n = 850)	Dirty (n = 811)
Overall complications	603 (4.81)	101 (9.06)	134 (15.76)	160 (19.73)
Overall surgical site infection	344 (2.75)	31 (2.82)	42 (4.94)	41 (5.06)
Superficial SSI	237 (1.89)	18 (1.64)	19 (2.24)	16 (1.97)
Deep SSI	80 (0.64)	7 (0.64)	19 (2.24)	18 (2.22)
Organ/Space SSI	34 (0.27)	7 (0.64)	4 (0.47)	8 (0.99)
Reoperation	404 (3.23)	68 (6.19)	100 (11.76)	154 (18.99)
Mortality	10 (0.08)	2 (0.18)	12 (1.41)	28 (3.45)

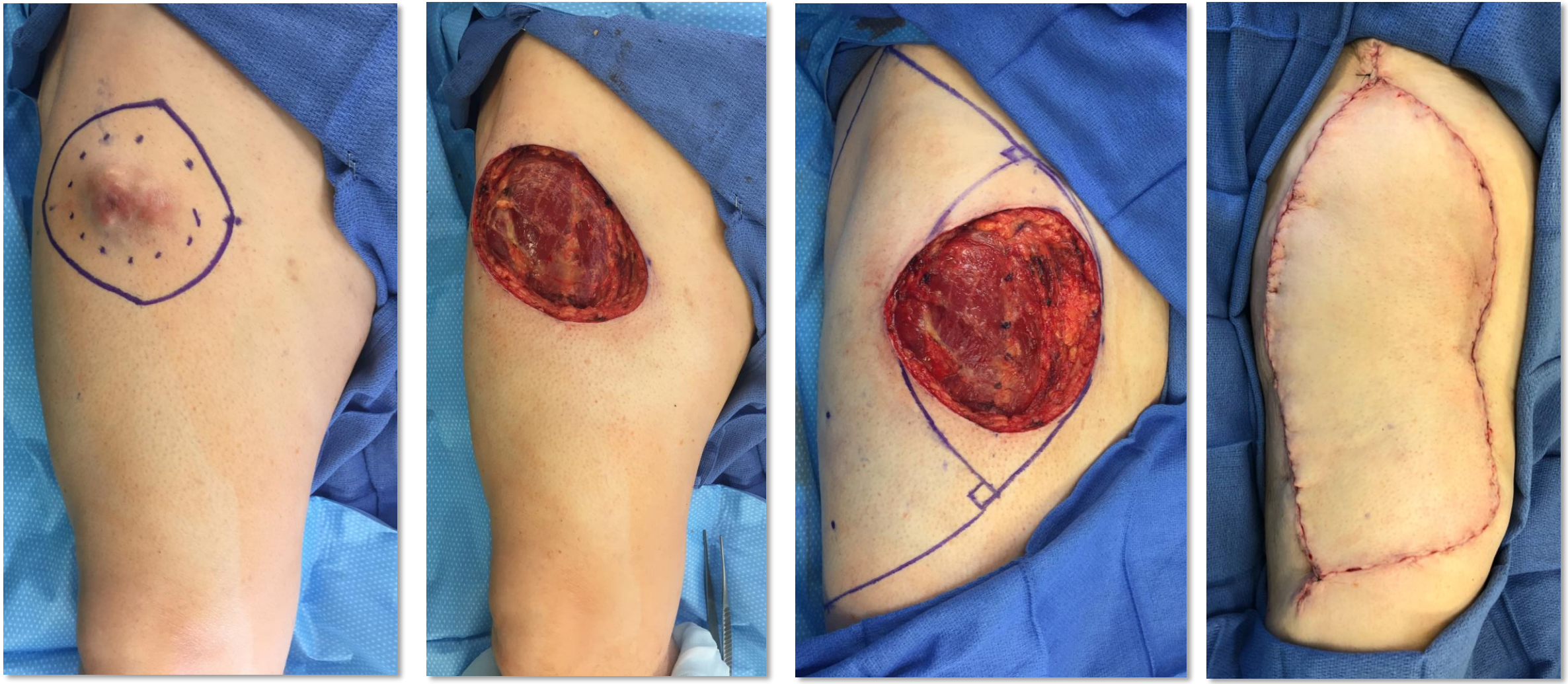
SSIs, surgical site infections.

Mioton LM, et al. *Arch Plast Surg.* 2013;40(5):522-9.

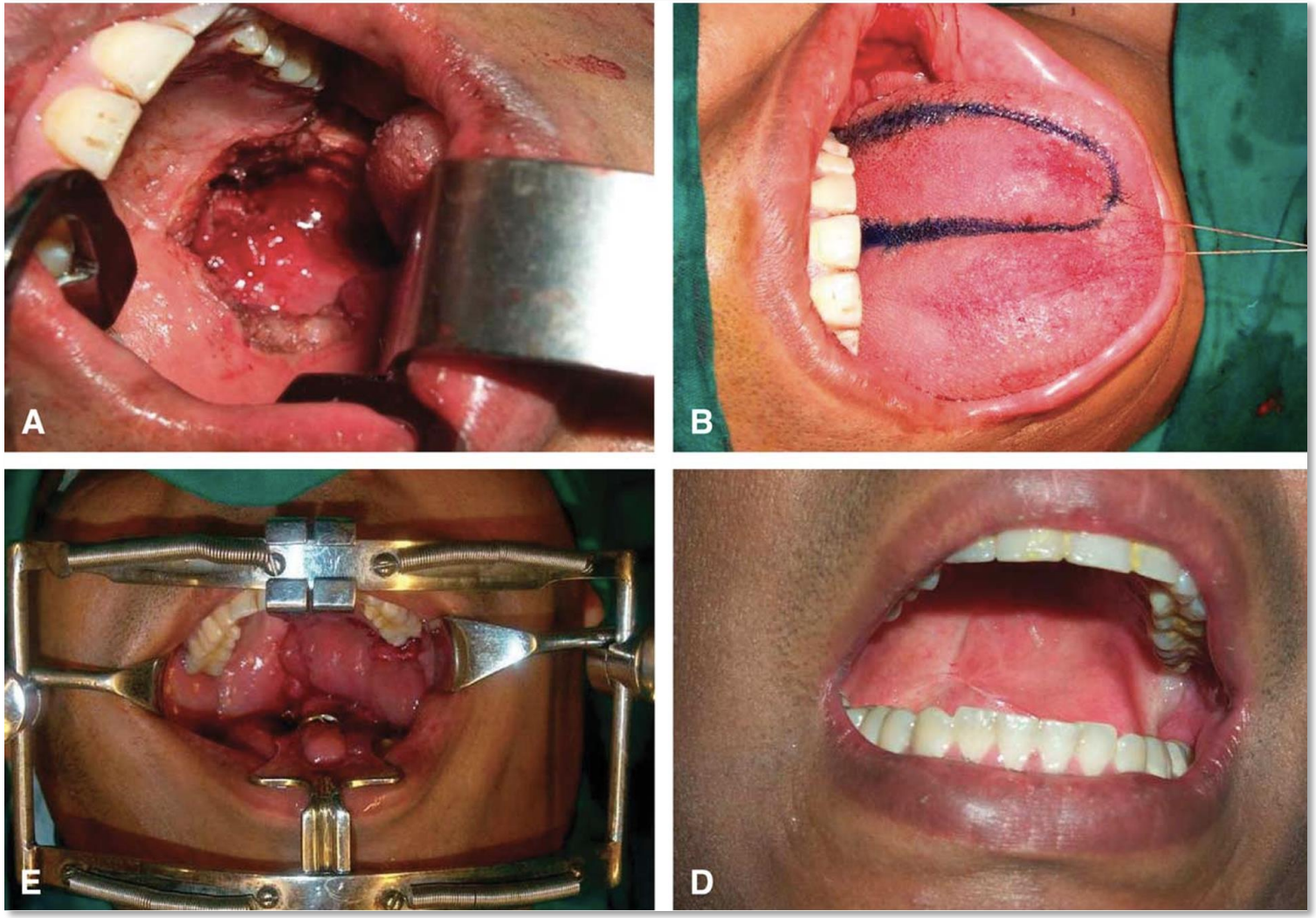
SSI Rates per Wound Class

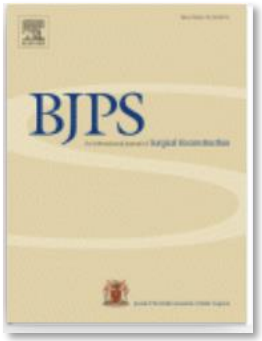
- Clean
  - 1%-5%
- Clean-Contaminated
  - 3%-11%
- Contaminated
  - 10%-17%
- Dirty/Infected
  - >27%

Clean Case:
DFSP Resection and Keystone Flap



Clean-Contaminated Case: Palatal Adenocarcinoma Tongue Flap Reconstruction





Joshi A, et al. *Br J Plast Surg*. 2005;58(8):1061-6.

Contaminated Case: Axillary Hidradenitis






Dirty/Infected Case:
Tree Fell on Car/Leg Crush




Clinical Pearls

- Most of my cases are CONTAMINATED or DIRTY/INFECTED cases
- How to modulate this with a goal of decreased SSI and more rapid wound healing?
  - Consideration for preoperative preparation of surgical site, ie, **highly charged fiber dressings, pHA wound irrigation**
  - Wide excision of necrotic/fibrotic/infected tissue
  - Consideration of **NPWT** and/or **INCISIONAL NPWT** and/or **NPWT with instillation and dwell**
  - Intraoperative wound irrigation with **pHA**
  - Plastic surgical wound closure techniques: **minimize tension**
  - **WIDE drainage** techniques
    - Closed-suction drains, iodine-impregnated gauze strips
  - Targeted **antibiotic** therapy
  - Close post-operative follow-up/incision cleansing with pHA post-op

Clinical Cases

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LLE Wound

- 75y Male
- Squamous cell carcinoma resected from LLE by his dermatologist
- Referred to wound center

- Wound has not healed 9 months later

LLE Wound

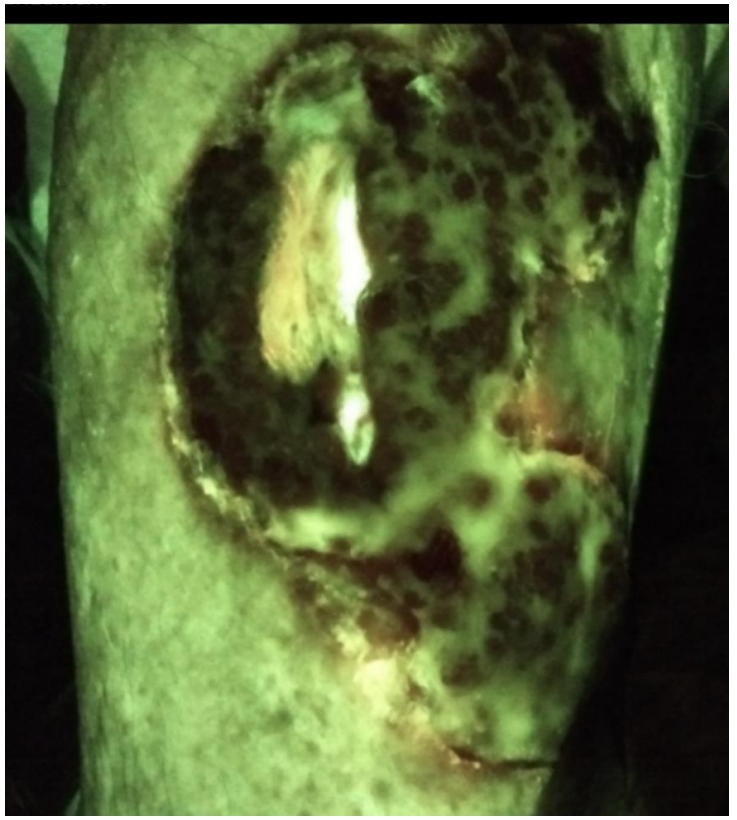
- Initiate pHA soaks and highly charged fiber dressing q2 days
- Plan for operative debridement of osteomyelitis

LLE Wound

- 1 wk later in outpatient wound center
- Sharp debridement
- Decreased slough

- Dessicated bone more clearly delineated

- Fluorescent imaging: improved




R
F

LLE Wound

- After OR debridement, pHA soak for 10 min
- Placement of OFM graft to build granulation tissue over the bone
- NPWT

- Plan for staged skin graft closure

LLE Wound

- 2 wks later
- Continuation of pHA soaks and NPWT outpatient

- Confluent granulation tissue seen over bone

LLE Wound

- 4 wks later
- Take back to OR for STSG
- NPWT

LLE Wound

- 8 weeks postop – HEALED!

Pyoderma Gangrenosum Wound

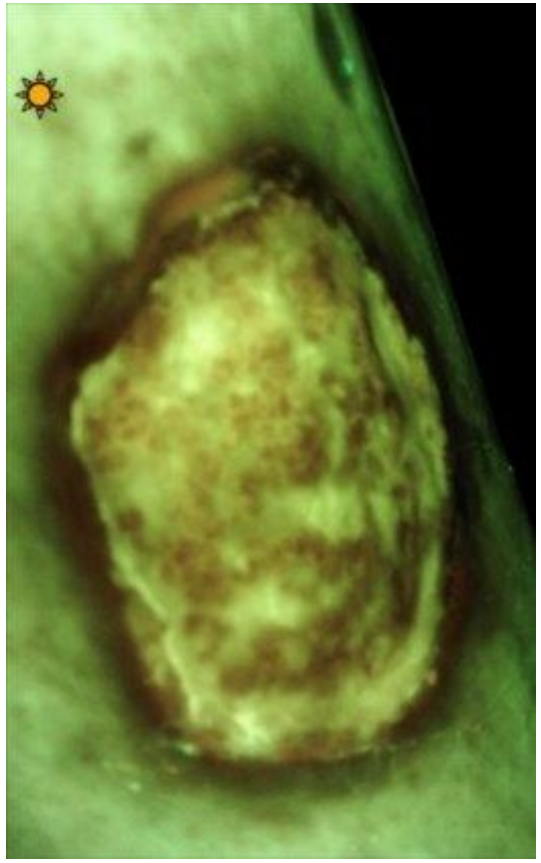
- 72y Female
- PMHx: Rheumatoid arthritis
- Spontaneous development of painful RLE wound with necrosis and slough

- Dermatology
  - Infliximab
  - Prednisone

Pyoderma Gangrenosum Wound

- Ultrasonic debridements performed
- Highly charged fiber dressing initiated with pHA soaks
- Fenestrations added to assist with heavy slough removal
- ABD and tubular compression dressing

Pyoderma Gangrenosum Wound



Current Techniques to Determine Levels of Contamination in Wounds

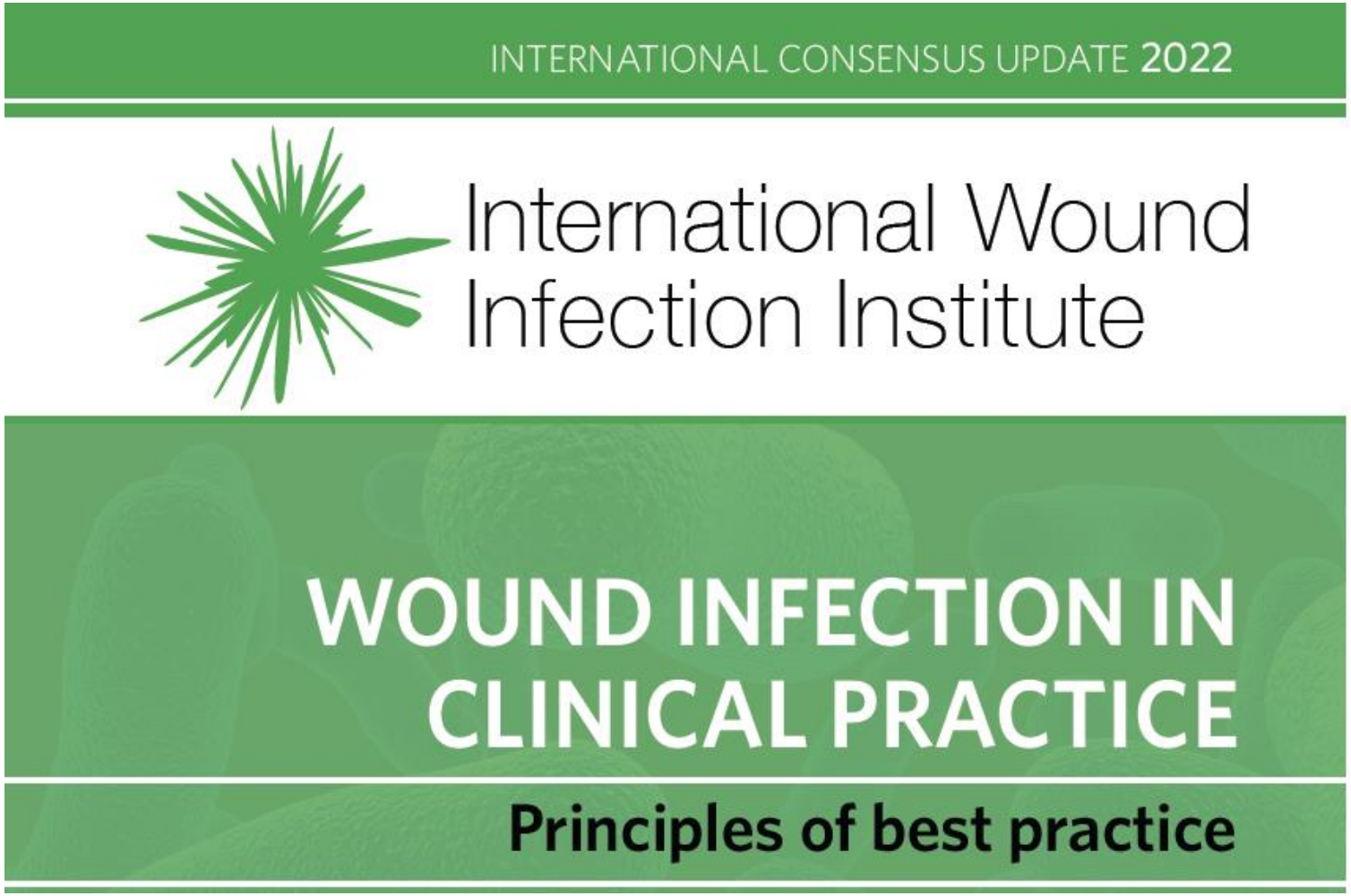
Lisa Gould, MD, PhD, FACS
South Shore Health, Weymouth, MA
Clinical Associate Professor,
Brown University Warren Alpert Medical School, Providence, RI
University of South Florida, Tampa, FL
Tufts University School of Medicine, Boston, MA

How to Diagnose Wound Infection

- Need at least 2 clinical signs
  - Increased drainage
  - Odor
  - Erythema
  - Wound deterioration
  - Increased pain

WARNING:

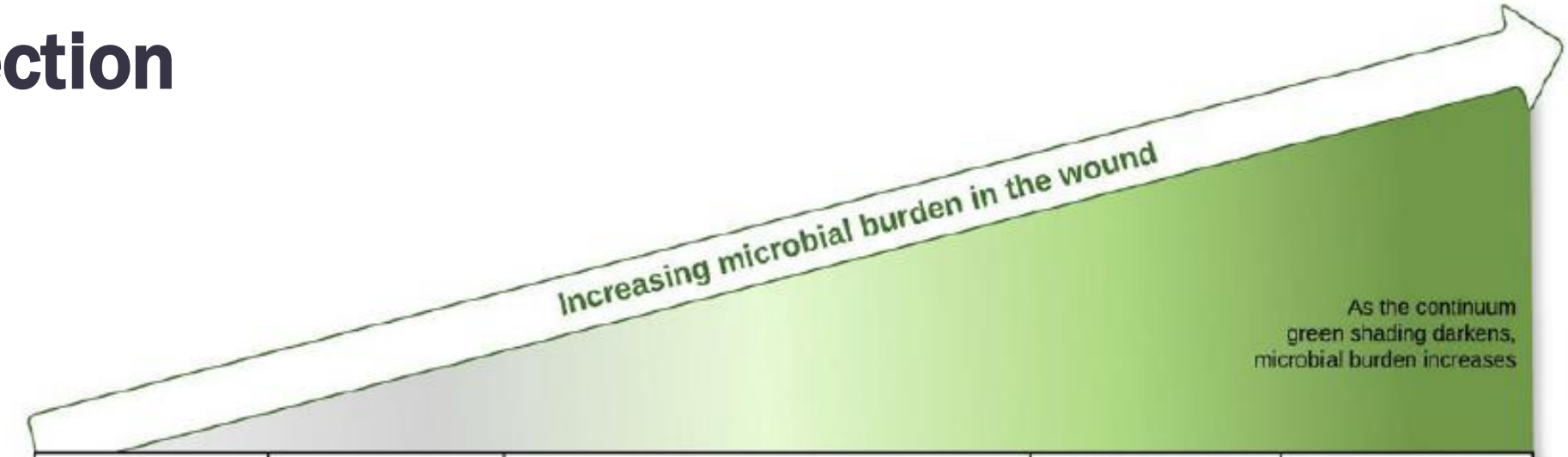
- Almost all bacteria may be pathogens
- Identification of a pathogen without clinical signs of infection ≠ infection



"The germ is nothing. It is the terrain in which it is found that is everything."
Louis Pasteur, 1880

Swanson T, Ousey K, Haesler E, Bjarnsholt T, Carville K, Idensohn P, Kalan L, Keast DH, Larsen D, Percival S, Schultz G, Sussman G, Waters N, Weir D. IWII Wound Infection in Clinical Practice consensus document: 2022 update. *J Wound Care*. 2022 Dec 1;31(Sup12):S10-S21.

Wound Infection Continuum



CONTAMINATION	COLONISATION	LOCAL WOUND INFECTION		SPREADING INFECTION	SYSTEMIC INFECTION
		COVERT (subtle)	OVERT (classic)		
• Microorganisms are present within the wound but are not proliferating • No significant host reaction is evoked • No delay in healing is clinically observed	• Microorganisms are present and undergoing limited proliferiation • No significant host reaction is evoked • No delay in wound healing is clinically observed	• Hypergranulation • Bleeding, friable granulation • Epithelial bridging and pocketing in granulation tissue • Increasing exudate • Delayed wound healing beyond expectations	• Erythema • Local warmth • Swelling • Purulent discharge • Wound breakdown and enlargement • New or increasing pain • Increasing malodour	• Extending induration • Spreading erythema • Inflammation or erythema >2cm from wound edge • Crepitus • Wound breakdown/ dehiscence with or without satellite lesions • Lymphangitis (swelling of lymph glands)	• Malaise • Lethargy or nonspecific general deterioration • Loss of appetite • Fever/pyrexia • Severe sepsis • Septic shock • Organ failure • Death

Only collect a wound sample in the presence of clinical signs and symptoms of wound infection.

Use an inert wound cleanser and debride the wound (if required) prior to collecting a wound specimen to avoid false positive results.

Tissue biopsy is the preferred wound specimen for obtaining accurate cultures. When this is not an option, use the Levine technique to collect a wound swab. This will express microbes from below the wound tissue.

Levine Swab Technique

Table 6. Concordance of qualitative swab and tissue cultures

	Wound exudate (%)	*Z*-technique (%)	Levine's (%)
All organisms			
Mean concordance	83	78	78
Staphyloccus aureus			
Total concordance	95	93	96
Occurrence concordance	91	88	94
Nonoccurrence concordance	90	85	92
Pseudomonas aeruginosa			
Total concordance	95	92	96
Occurrence concordance	69	56	75
Nonoccurrence concordance	95	91	96
Groups A or B *Streptococcus*			
Total concordance	99	99	99
Occurrence concordance	67	67	67
Nonoccurrence concordance	99	99	99

N=83.

- Cleanse with sterile saline (not antibacterial)
- Sample 1 cm^2 area with sufficient pressure to obtain tissue fluid
- Most reflective of tissue microbes

Levine, et al. 1976.

Gardner SE, et al. Diagnostic validity of three swab techniques for identifying chronic wound infection. WRR. 2006 Sep-Oct;14(5):548-57

Essen Rotary Swab Technique

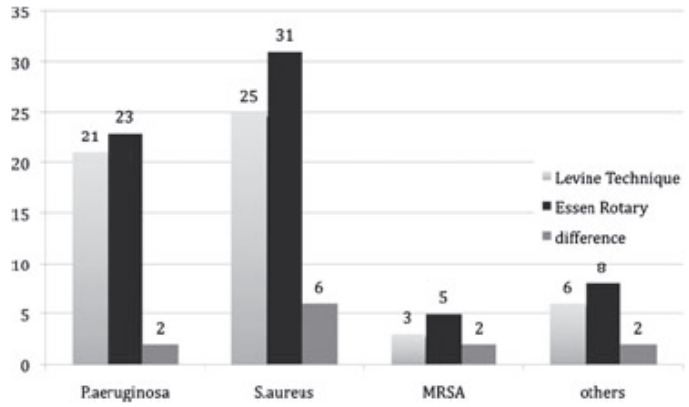
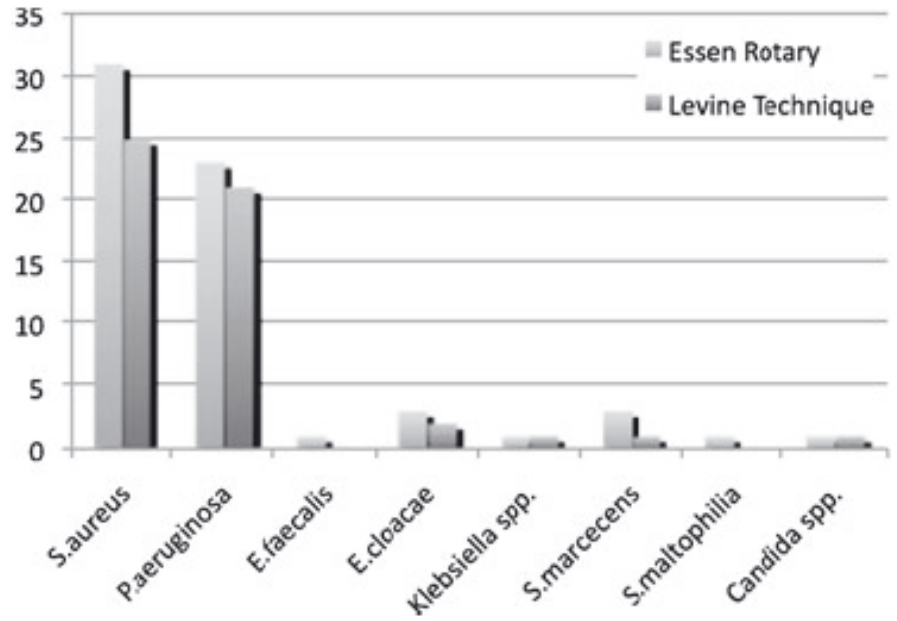


Figure 5 Direct comparison of the absolute results. Essen Rotary vs. conventionally performed swab according to the Levine technique.

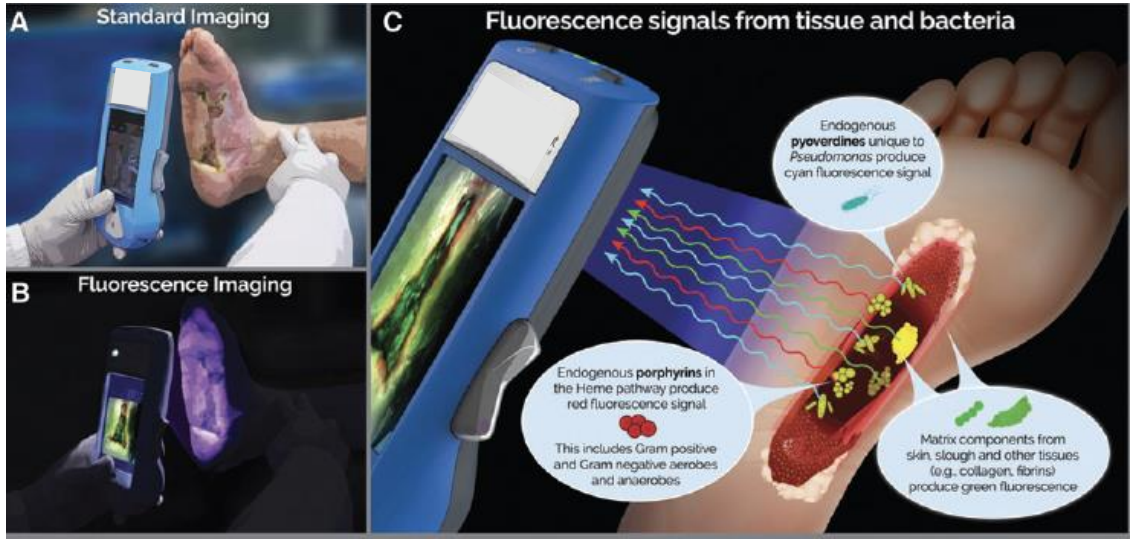


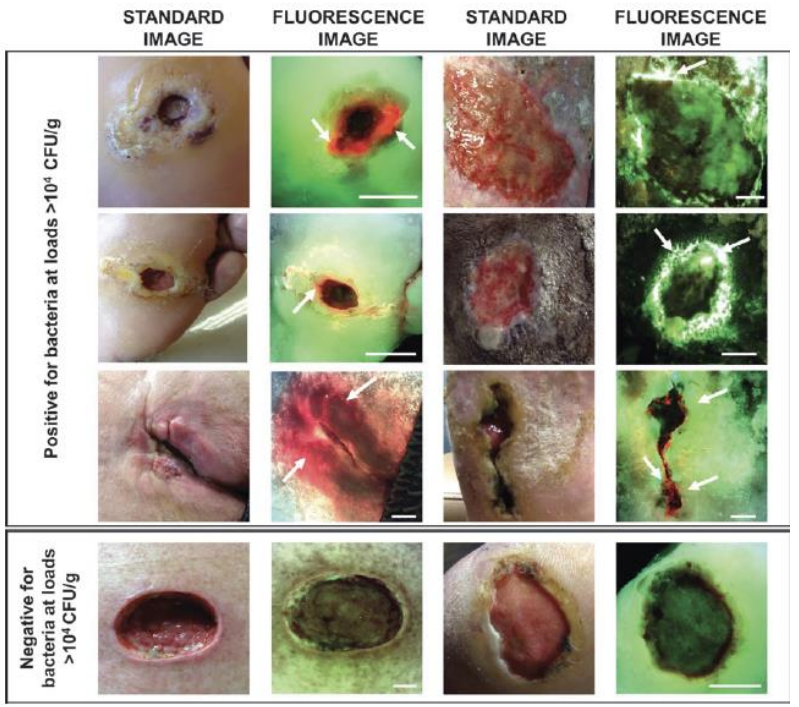
Al Ghazal P, Körber A, Klode J, Schmid EN, Buer J, Dissemond J. Evaluation of the Essen Rotary as a new technique for bacterial swabs: results of a prospective controlled clinical investigation in 50 patients with chronic leg ulcers. *Int Wound J.* 2014 Feb;11(1):44-9.

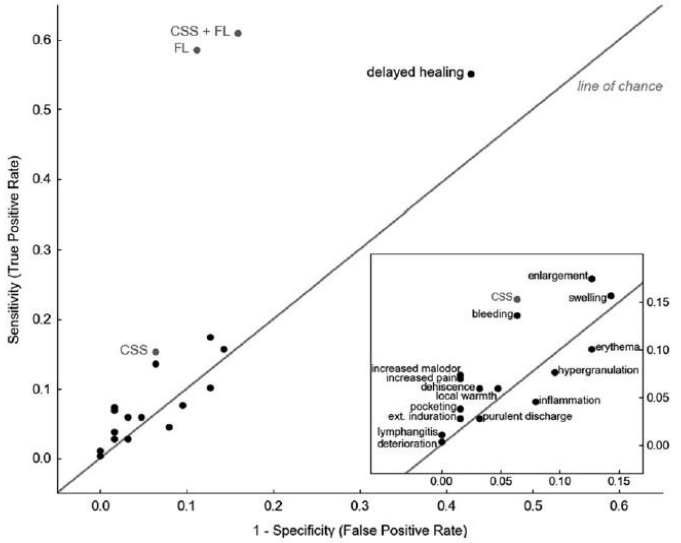
Non-Specific Options

- Temperature
- pH
- Inflammatory markers
- Xrays and other imaging

Point of Care Technology





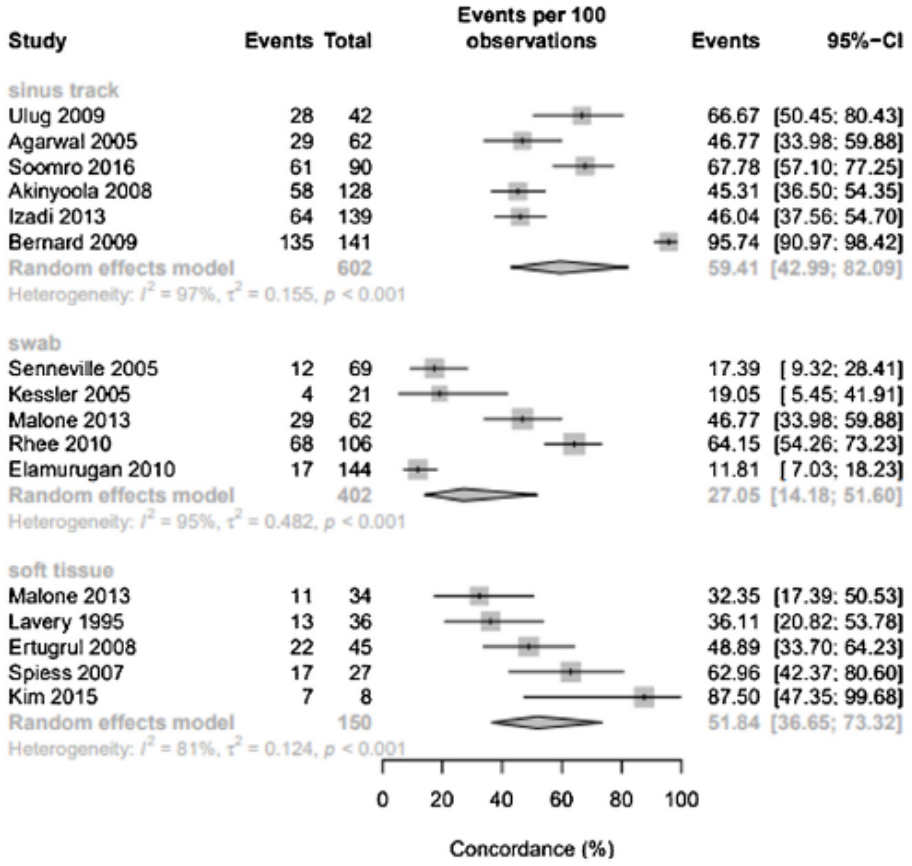


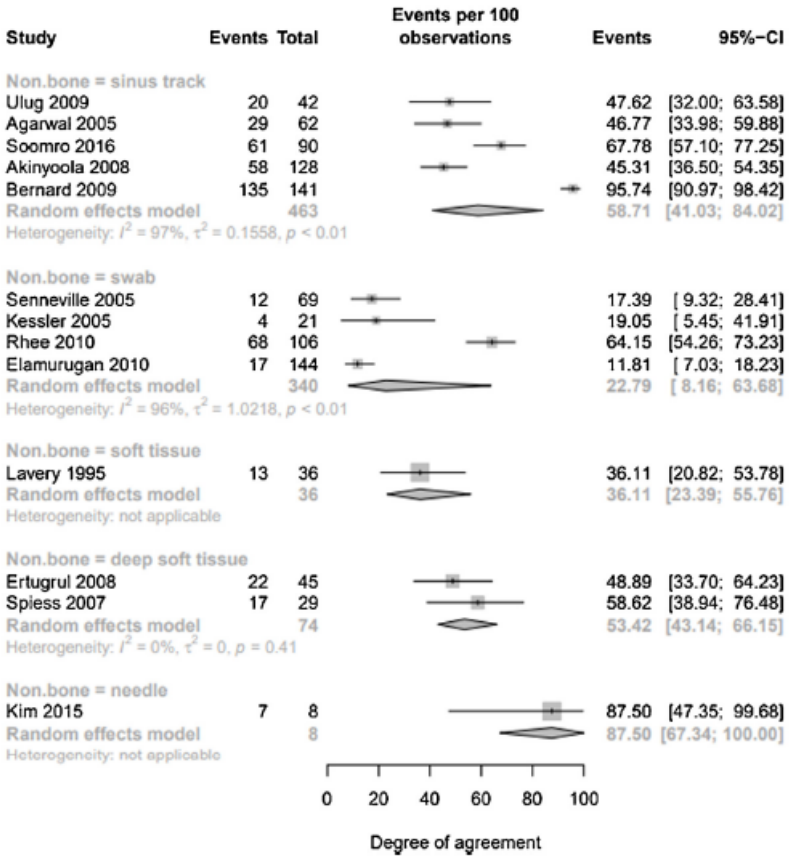
Lam L, et al. *Adv Wound Care.* 2020;10:123-136.

What about PCR?

- When the references are old, and the number of advertisements exceeds the number of scientific papers, I get worried…
  - Ragothaman KK, et al. Evaluation of Polymerase Chain Reaction in the Identification and Quantification of Clinically Relevant Bacterial Species in Lower Extremity Wound Infections, *The Journal of Foot and Ankle Surgery.* 2022;61(4):713-718
    - Faster
    - Higher sensitivity
    - Unable to identify sensitivity to antibiotics
    - Unable to demonstrate clearance of species
- Commercial Enterprises
  - GENETWORx
  - Precision Life Sciences
  - Wound Care PCR Testing, Golden Point Labs
  - Advanced Wound Care (mobile wound care)
  - CoreBioLabs

Intra-Operative Cultures





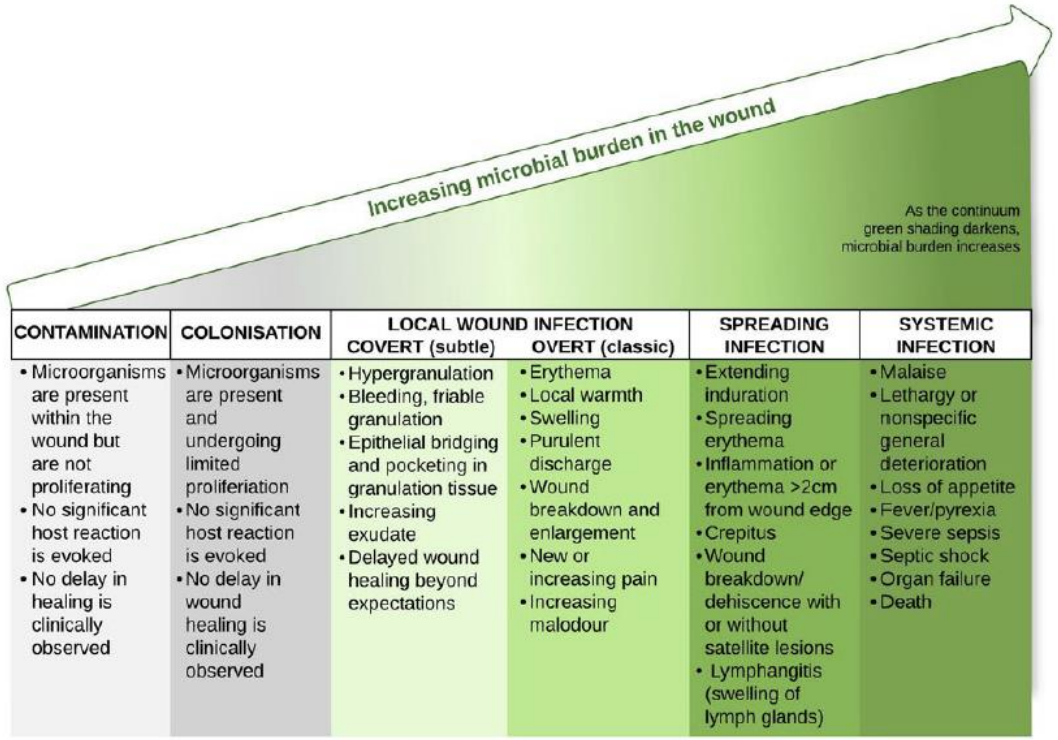
Tawfik GM, Dibas M, Dung NM, Alkhebairy AA, Mahmoud MH, Ibrahim MH, Abd Elhady NR, Sayed AM, Gehad AS, Abdelrahman AS, Elfaituri MK, Nam NH, El-Qushayri AE, Huy NT. Concordance of bone and non-bone specimens in microbiological diagnosis of osteomyelitis: A systematic review and meta-analysis. *J Infect Public Health*. 2020 Nov;13(11):1682-1693

What Don’t We Have (Yet)?

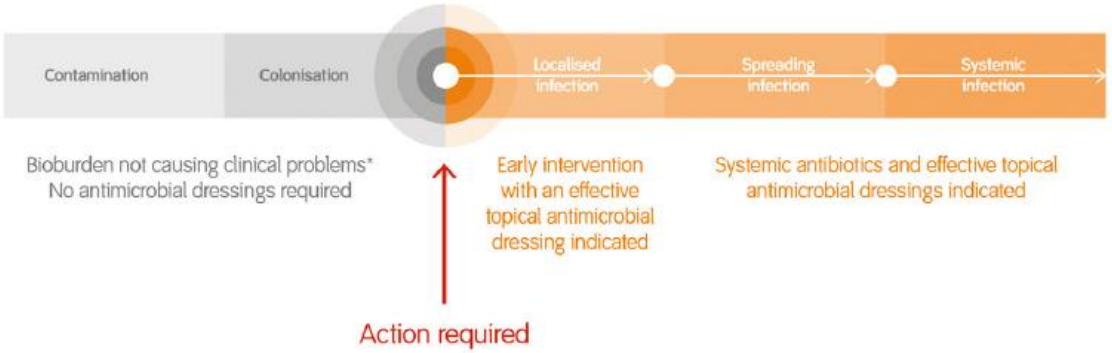
- True point-of-care diagnostic
- Rapid fungal culture
- Biofilm diagnostics
- Method to determine the pathogen

What Is the Role of Topical Antimicrobials and Systemic Antibiotics in the Management of Wound Infection?

Appropriate Use of Antimicrobials

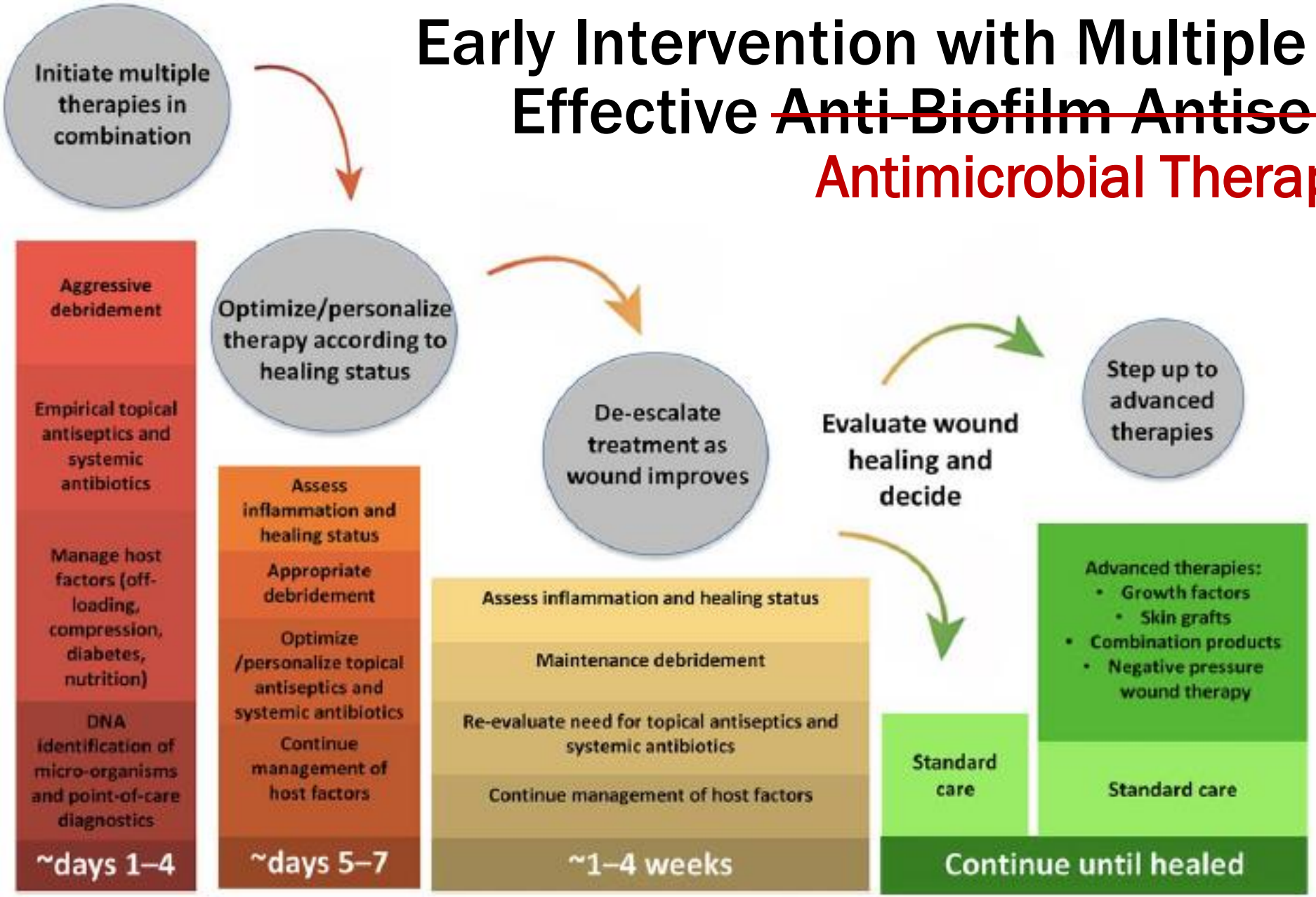


CONTAMINATION	COLONISATION	LOCAL WOUND INFECTION COVERT (subtle)	LOCAL WOUND INFECTION OVERT (classic)	SPREADING INFECTION	SYSTEMIC INFECTION
• Microorganisms are present within the wound but are not proliferating • No significant host reaction is evoked • No delay in healing is clinically observed	• Microorganisms are present and undergoing limited proliferiation • No significant host reaction is evoked • No delay in wound healing is clinically observed	• Hypergranulation • Bleeding, friable granulation • Epithelial bridging and pocketing in granulation tissue • Increasing exudate • Delayed wound healing beyond expectations	• Erythema • Local warmth • Swelling • Purulent discharge • Wound breakdown and enlargement • New or increasing pain • Increasing malodour	• Extending induration • Spreading erythema • Inflammation or erythema >2cm from wound edge • Crepitus • Wound breakdown/ dehiscence with or without satellite lesions • Lymphangitis (swelling of lymph glands)	• Malaise • Lethargy or nonspecific general deterioration • Loss of appetite • Fever/pyrexia • Severe sepsis • Septic shock • Organ failure • Death



Swanson T, Ousey K, Haesler E, Bjarnsholt T, Carville K, Idensohn P, Kalan L, Keast DH, Larsen D, Percival S, Schultz G, Sussman G, Waters N, Weir D. IWII Wound Infection in Clinical Practice consensus document: 2022 update. *J Wound Care*. 2022;31(Sup12):S10-S21. Woodmansey EJ, Roberts CD. *Int Wound J.* 2018;15:1025–1032.

Early Intervention with Multiple Therapies and Effective ~~Anti-Biofilm Antiseptics~~ Is Key Antimicrobial Therapy

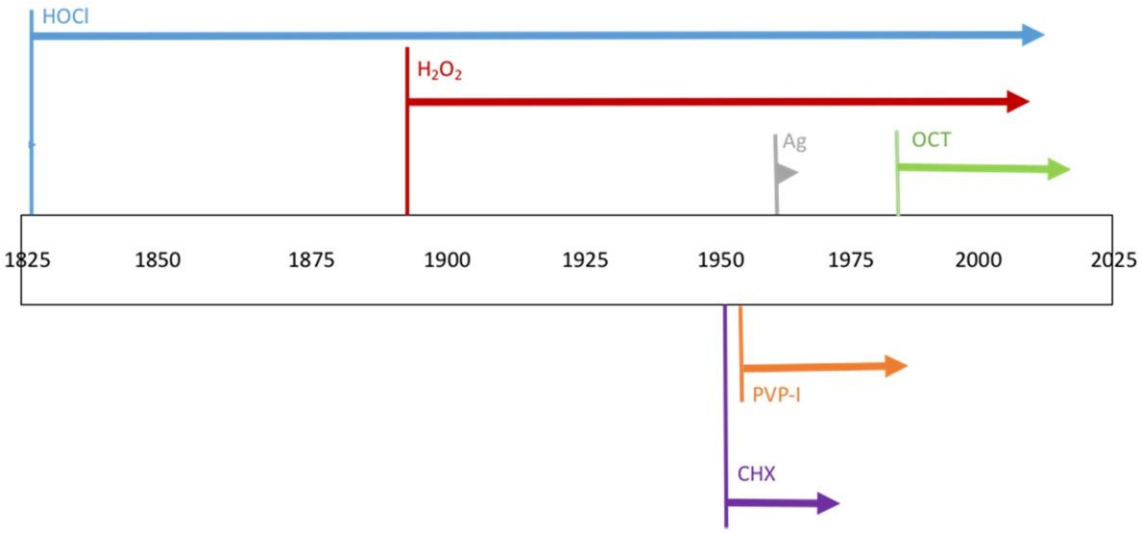


Modified from: Schultz G, et al. *Wound Repair Regen*. 2017;25(5):744-757.

Specifically for This Presentation

- Silver
- Iodine
- Acetic acid
- Systemic antibiotic

- But there are many other things that people put in wounds to kill bacteria
  - Hypochlorous acid
  - PHMB
  - Sodium hypochlorite
  - Hydrogen peroxide
  - Methylene blue
  - Gentian violet
  - Chlorhexidine
  - Even antibiotics!



JAC Antimicrob Resist. 2021;3(1):dlab027, https://doi.org/10.1093/jacamr/dlab027

Silver

Cytotoxic to bacteria, viruses, yeast, and fungi

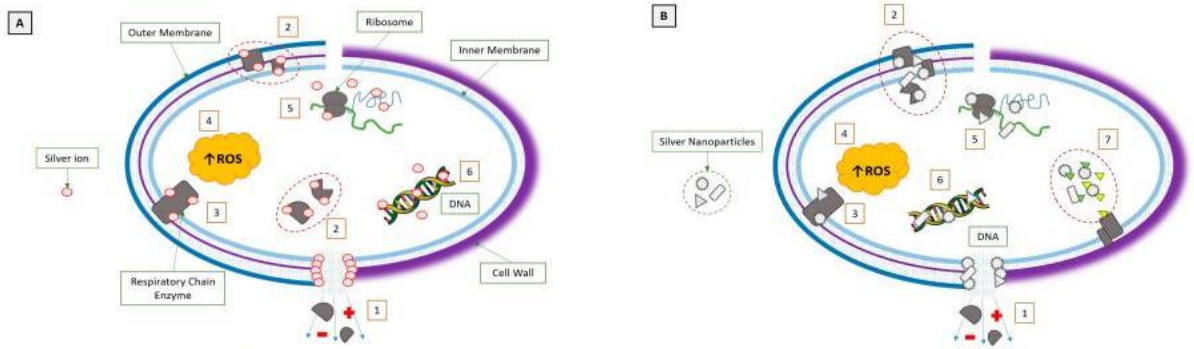
- Active against resistant organisms
  - MRSA
  - VRE
  - *P. aeruginosa*
  - CRE

Silver ≠ Silver

1. Oxidation state
   a. Ag^0
   b. Ag^+
   c. Ag^{++}
   d. Ag^{+++}
2. Structure
   a. Silver sulfadiazine (Silvadene)
   b. Nanocrystalline
   c. Ionic silver
3. Concentration
   a. Bactericidal at 30-40ppm
   b. Toxic to keratinocytes and fibroblasts in high concentration (60ppm in collagen lattice)
   c. Systemic toxicity is rare (>60ppm)

Mechanism of Action

1. Cell wall and membrane disruption
2. Denaturing of proteins and enzymes
3. Preventing respiration
4. Inhibiting DNA synthesis



Pletts MW, Burrell RE. *Wound Repair Regen*. 2025;33(1):e13249. Woodmansey EJ, Roberts CD. *Int Wound J*. 2018;15:1025–1032. Kędziora A, et al. *Int J Mol Sci*. 2018;19(2):444.

Topical Antimicrobial Dressings

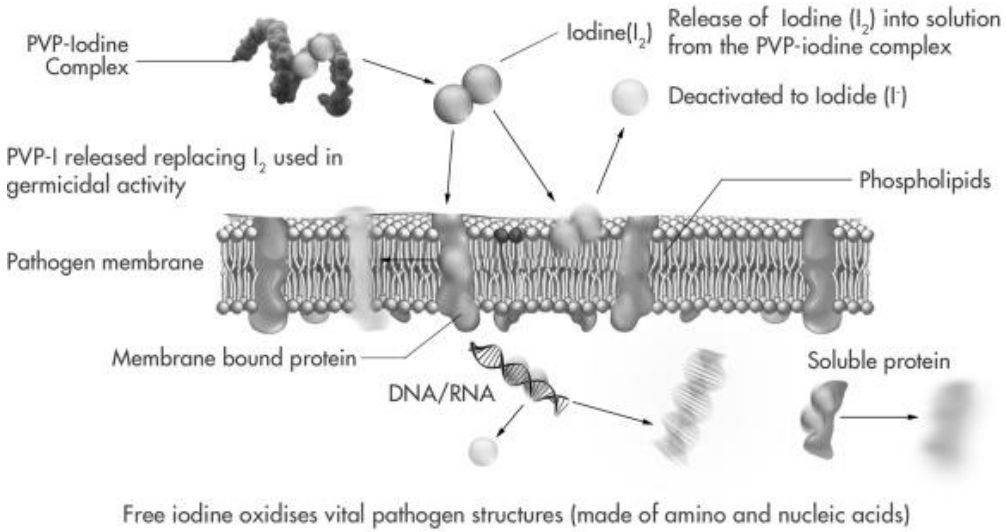
Table 12: Clinical evidence for topical antiseptics in complete wound healing¥

Preparation	Evidence from reviews and randomised and/or controlled trials
Alginogel	No difference in complete healing rate for burns versus silver sulfadiazine dressing[288]
Cadexomer iodine	■ Higher complete healing rates for pressure injuries,[285] venous leg ulcers[289] and in chronic wounds[290] versus standard care ■ Higher complete healing at 12 weeks with 0.9% cadexomer iodine in both gel and powder forms versus standard care[291]
DACC	Higher complete health rates at 75 days for pilonidal sinus versus alginate dressing[292]
Honey	Higher rates of complete healing for surgical wounds versus EUSOL[284] ■ Higher complete healing rates for superficial burns versus silver sulfadiazine[293] ■ Higher complete healing rates for burns versus topical antibiotics[283] and versus silver sulfadiazine[294] ■ Higher complete healing rates for VLUs versus alternative dressings[289] ■ Higher complete healing ates for minor wounds versus standard care[294]
OCT	■ Similar complete healing rates for chronic leg ulcers with OCT versus Ringer's solution[295] ■ Complete healing was significant for partial thickness burns with OCT gel, similar rates to herbal gel[296]
PHMB	Higher rates of chronic wound healing with a PHMB dressing versus a silver dressing[186, 297]
Povidone iodine	Inferior complete healing rates for pressure injuries versus protease modulating dressing[285] ■ Conflicting findings for complete healing versus non-antimicrobial dressings with no difference shown for chronic ulcers[298] or donor-sites,[299] but faster healing shown for diabetic foot ulcers (DFUs)[299] ■ Reduction in time to complete healing in burns[283]
SOS	Improved healing for chronic wounds with no difference in healing outcomes for SOS versus tetrachlorodecaoxide[300] ■ Higher rates of chronic wound healing for SOS versus povidone iodine[301-303] ■ Faster complete healing of burns for sodium hypochlorite versus silver sulfadiazine[283]
Silver	■ Higher rates of healing for venous leg ulcers (VLUs)[286] and for burns[283] with silver dressings versus non-antimicrobial dressings ■ No difference in healing rates for burns between nanocrystalline silver dressing versus any other silver-impregnated dressings[304] ■ Higher rates of healing for chronic wounds[305] and for VLUs[286] with silver dressings versus antimicrobial dressings ■ Higher rates of healing for pressure injuries with silver sulfadiazine versus povidone iodine[285] ■ Higher rates of healing for DFUs with nanocrystalline silver dressing versus honey or nonactive dressing[306] ■ Lower or similar rates of healing for burns with silver sulfadiazine versus a range of other comparators[307, 308]

¥ reported as complete wound closure within 8–12 weeks

Swanson T, Ousey K, Haesler E, Bjarnsholt T, Carville K, Idensohn P, Kalan L, Keast DH, Larsen D, Percival S, Schultz G, Sussman G, Waters N, Weir D. IWII Wound Infection in Clinical Practice consensus document: 2022 update. J Wound Care. 2022 Dec 1;31(Sup12):S10-S21.

Iodine

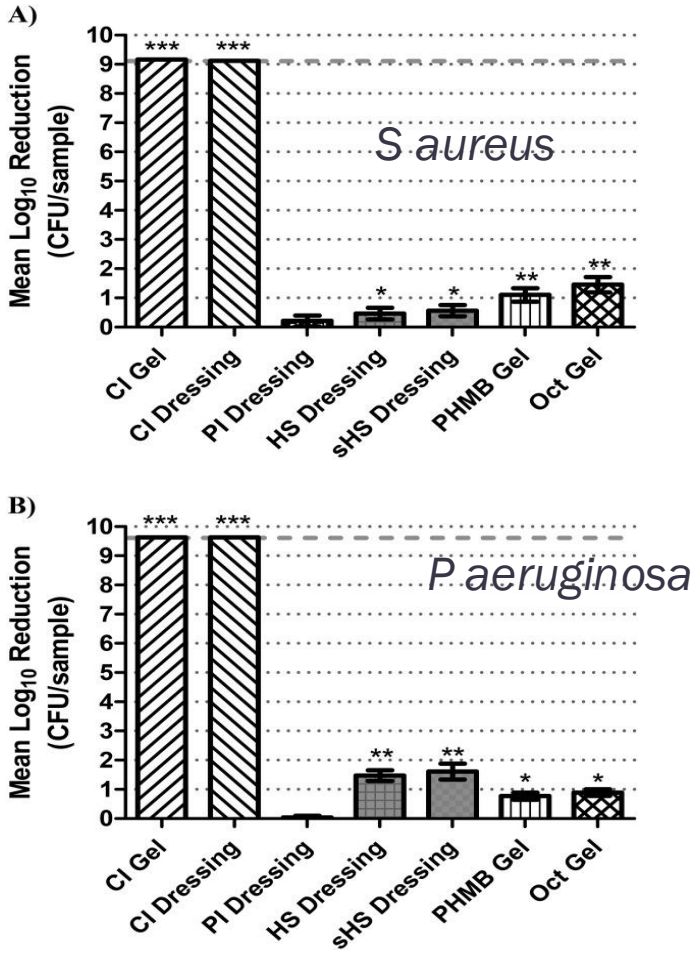


Three types of iodophors used in wound dressings in the U.S.

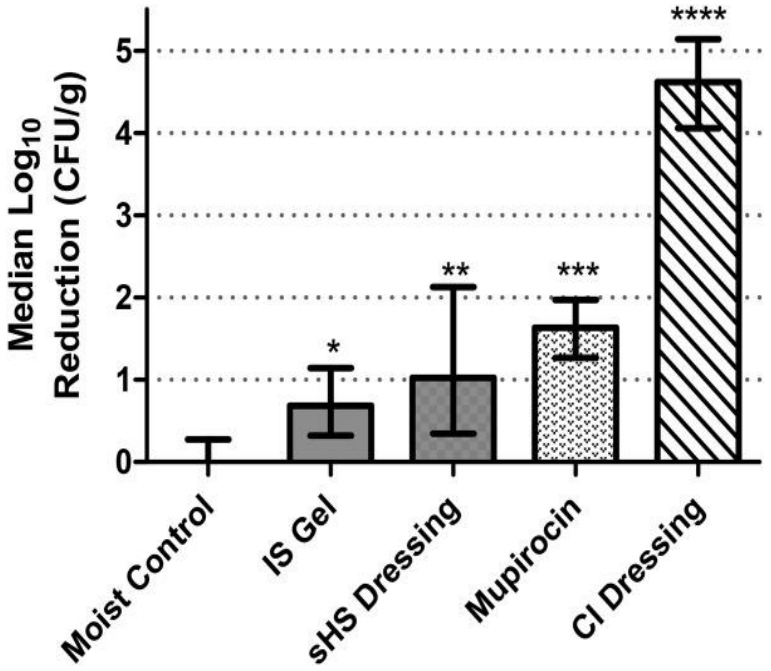
- **Cadexomer iodine:** produced by the reaction of dextrin with epichlorohydrin and iodine
- **Povidone iodine:** a liquid chemical complex of povidone, hydrogen iodide, and elemental iodine
- **Absorptive PVA-based foam dressing:** a newer iodophor—the exact chemical structure of which has not yet been fully determined—which is specifically indicated for use on infected wounds

Cadexomer Iodine Provides Superior Efficacy Against Bacterial Wound Biofilms In Vitro and In Vivo

In vitro



In vivo



MRSA mature biofilm

DRESSINGS

CI = cadexomer iodine

PI = povidone iodine

IS = ionic silver gel

HS = hydrofiber silver

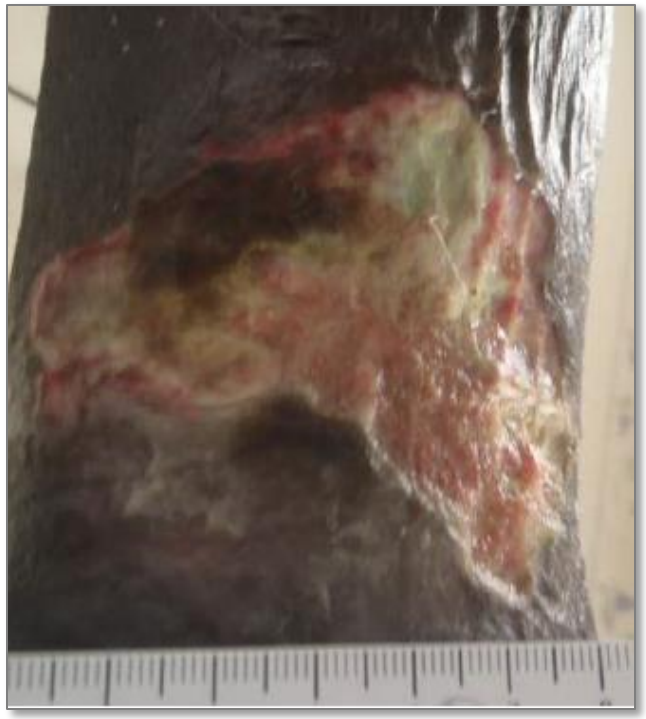
sHS = supplemented HS

PHMB = polyhexamethylene biguanide gel

Oct = octenidine gel

Wound Repair Regeneration, Volume: 25, Issue: 1, Pages: 13-24, First published: 17 November 2016, DOI: (10.1111/wrr.12497)

Wound Bed Preparation with Cadexomer Iodine



62y immunosuppressed, renal transplant with right leg ulcer, worsening with local wound care. Painful with foul, green drainage.

Cadexomer Iodine

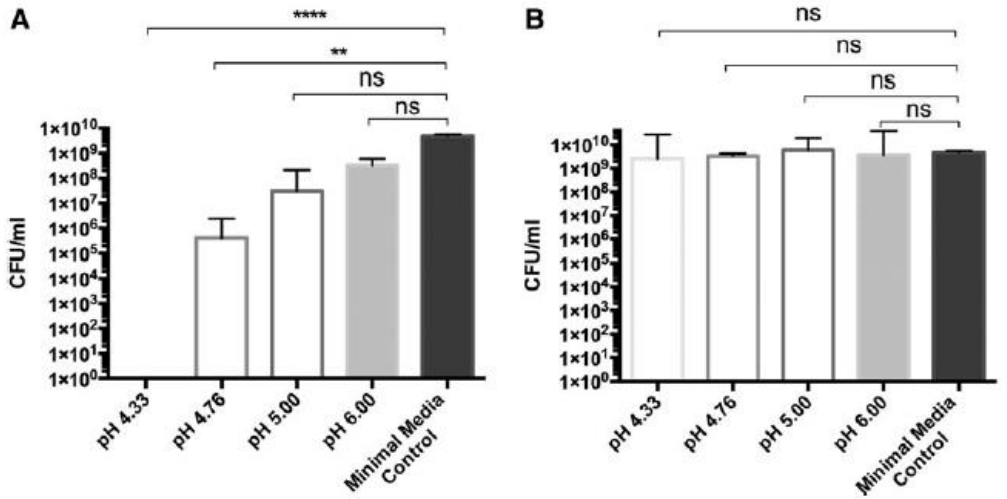
3 Wks after Outpatient Pixel Graft

- Persistent *pseudomonas* in wound
- Patches of graft visible in wound bed
- No migration

Acetic Acid

- Acetic acid eradicates mature biofilms
- It is the acetic acid molecule itself, in its nondissociated form, that kills bacteria: CH3COOH
- Maximal antibacterial effect at pH 4.76 and lower

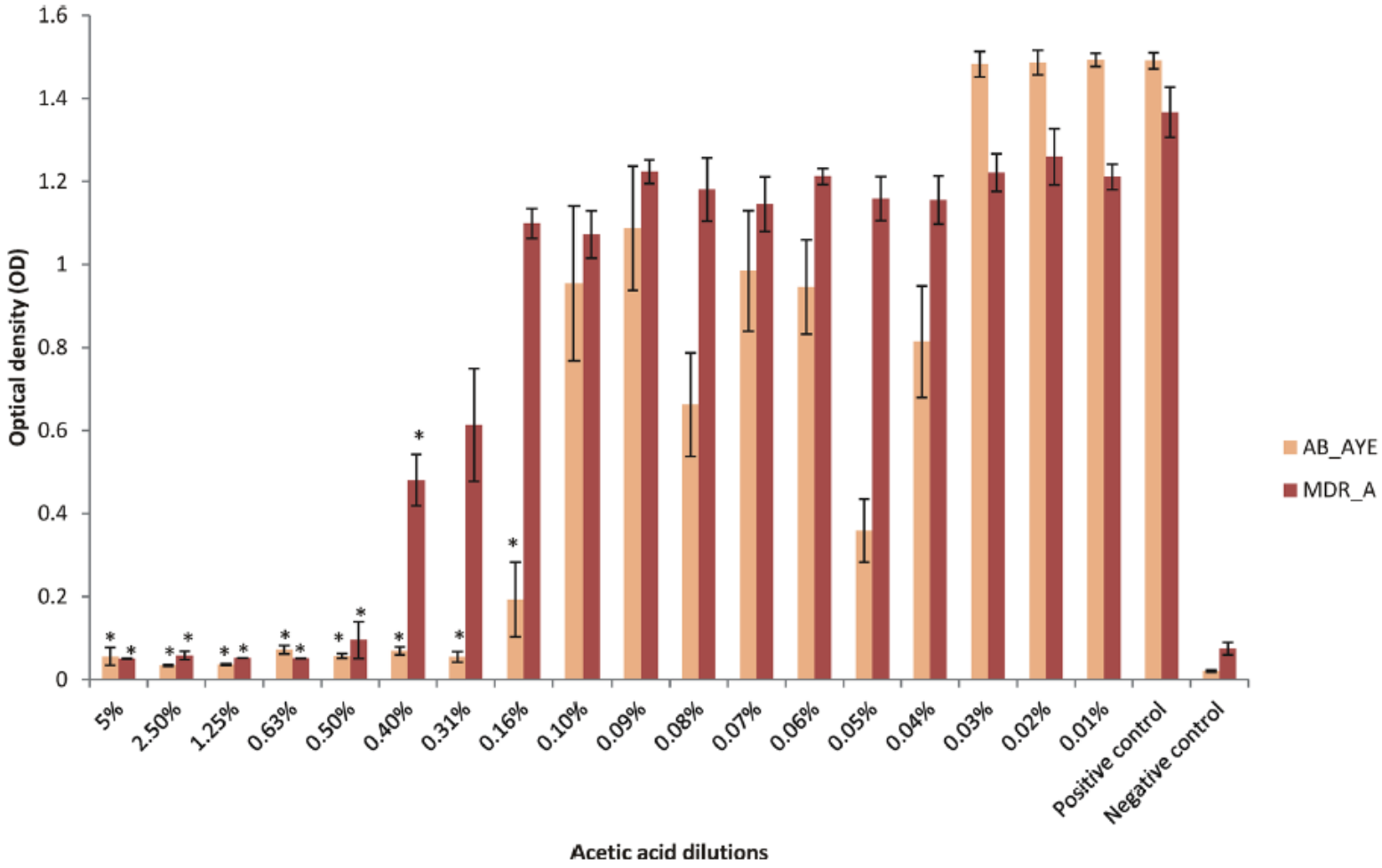
$$CH_3COOH \rightarrow CH_3COO^- + H^+ (pH > 4.76)$$
$$CH_3COOH \leftarrow CH_3COO^- + H^+ (pH < 4.76)$$
$$CH_3COOH = CH_3COO^- + H^+ (pH = 4.76)$$



Acetic acid **Hydrochlorous acid**

Bjarnsholt T, et al. *Adv Wound Care* (New Rochelle). 2015;4(7):363-372.

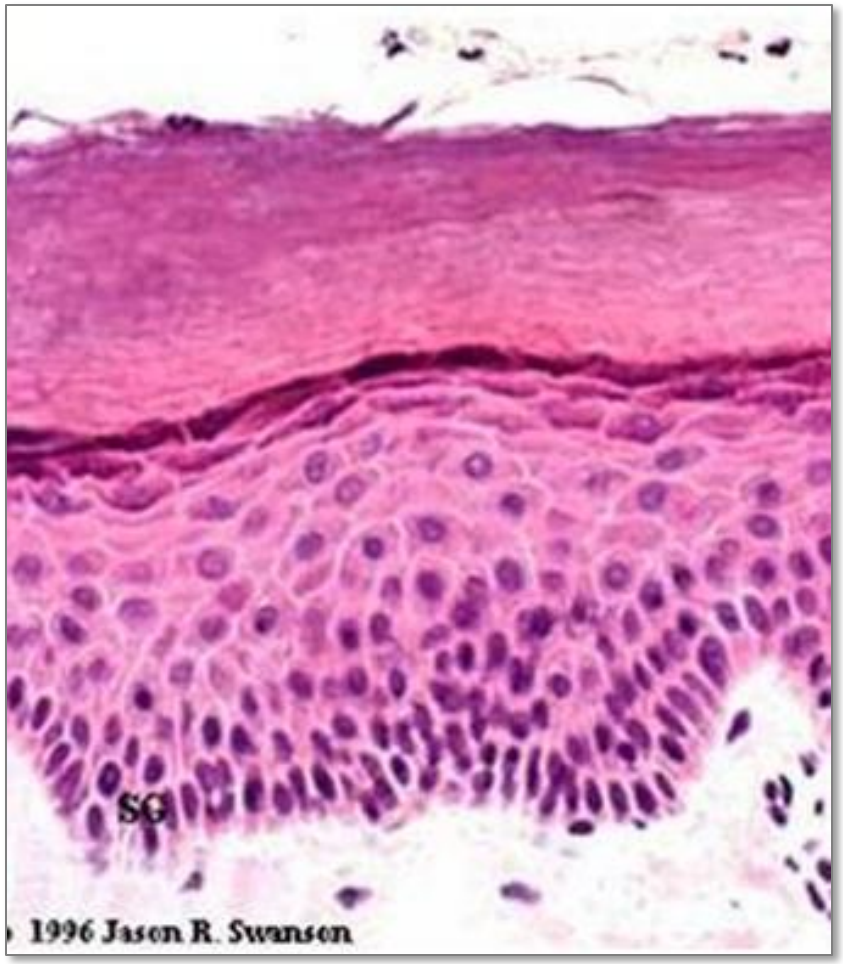
Impact of Acetic Acid on Mature Biofilm



Halstead FD, et al. *PLoS ONE.* 2015;10(9):e0136190.

Persisters Eradicated

Epidermal Skin Barrier Restored



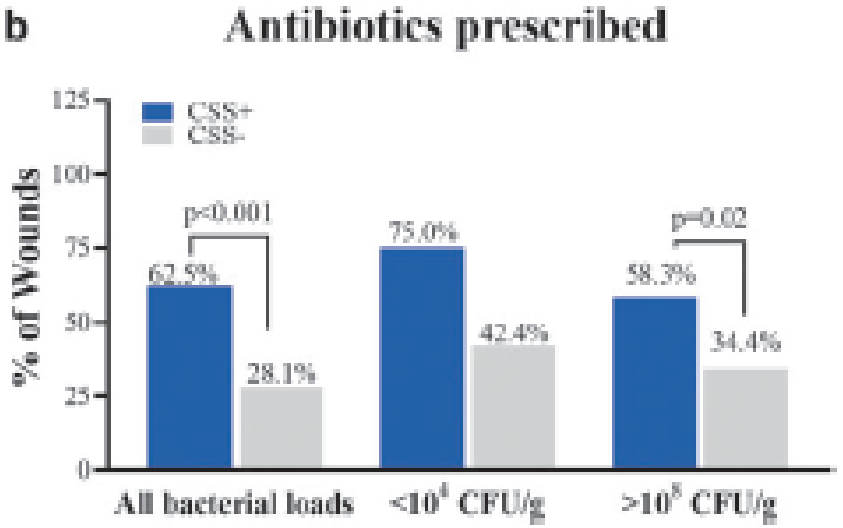
Houston – We Have a Problem…

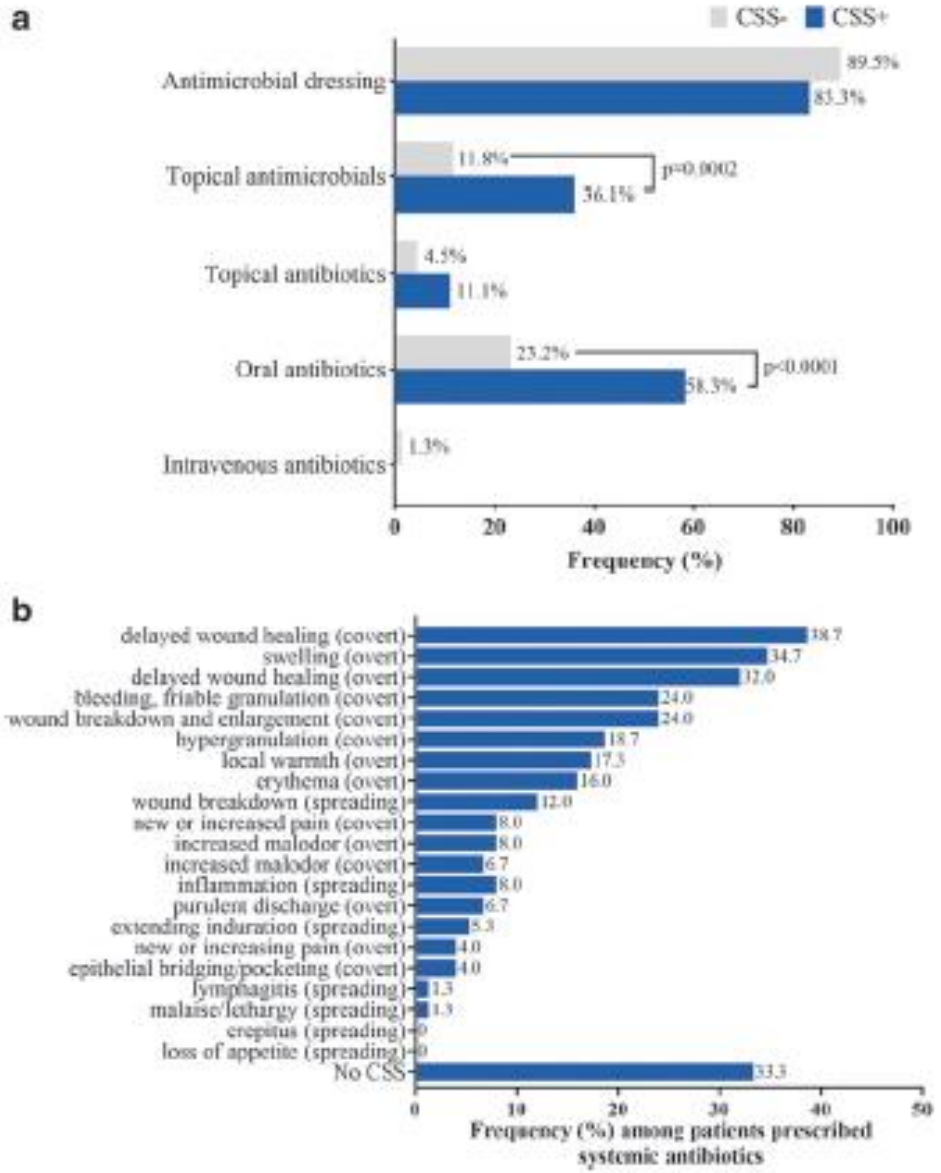
100 cases, 12 nursing homes in Denver

- Most common infections
  - Non-purulent cellulitis (*n* = 55)
  - Wound infection (*n* = 27)
  - Infected ulcer (*n* = 8)
  - Cutaneous abscess (*n* = 7)
- 26 cases previously published minimum clinical criteria for initiating were not met
  - 52 were initiated as a telephone order following a call from a nurse
  - 41 patients were not evaluated by a provider within 48 h after initiation of antibiotics
- 95 were treated with oral antibiotics alone
  - Median treatment duration was 7 days
  - 43 patients received treatment courses of ≥10 days

Yogo N, et al. Clinical Characteristics, Diagnostic Evaluation, and Antibiotic Prescribing Patterns for Skin Infections in Nursing Homes. *Front Med* (Lausanne). 2016;21(3):30.

Antibiotics Treat Infection, Not Wounds





Serena TE, Gould L, Ousey K, Kirsner RS. Reliance on Clinical Signs and Symptoms Assessment Leads to Misuse of Antimicrobials: *Post hoc* Analysis of 350 Chronic Wounds. *Adv Wound Care* (New Rochelle). 2022;11(12):639-649.

Dos and Don’ts of Infection Management in Wound Care

- **Don’t** forget the management of underlying comorbidities and concomitant factors
- **Don’t** perform routine swabs for all chronic wounds
- **Don’t** use topical antibiotics indiscriminately
- **Don’t** use systemic antibiotics indiscriminately

- **Do use wound hygiene as the #1 strategy**
- **Do use debridement for wound bed preparation**
- **Do use a multi-disciplinary team**
- **Do use culture-guided antibiotics for severe infections**

NPWT with Irrigation

Pressure Ulcer Decision-Making

At request of WOCN:

- 82y Male, admitted from skilled nursing facility (SNF)
- Evaluated together at bedside
  - Reviewed palliative care note and discussed patient's goals of care with team before proceeding

DTI

Demarcation

Bedside debridement

Pressure Ulcer Debridement → iNPWT

- Combined with WOCN re: best treatment strategy
- Discussed with hospitalists and Case Manager regarding length of stay, discharge to SNF, and capacity of the SNF for NPWT

7/7

8/6

Discharged to SNF with NPWT

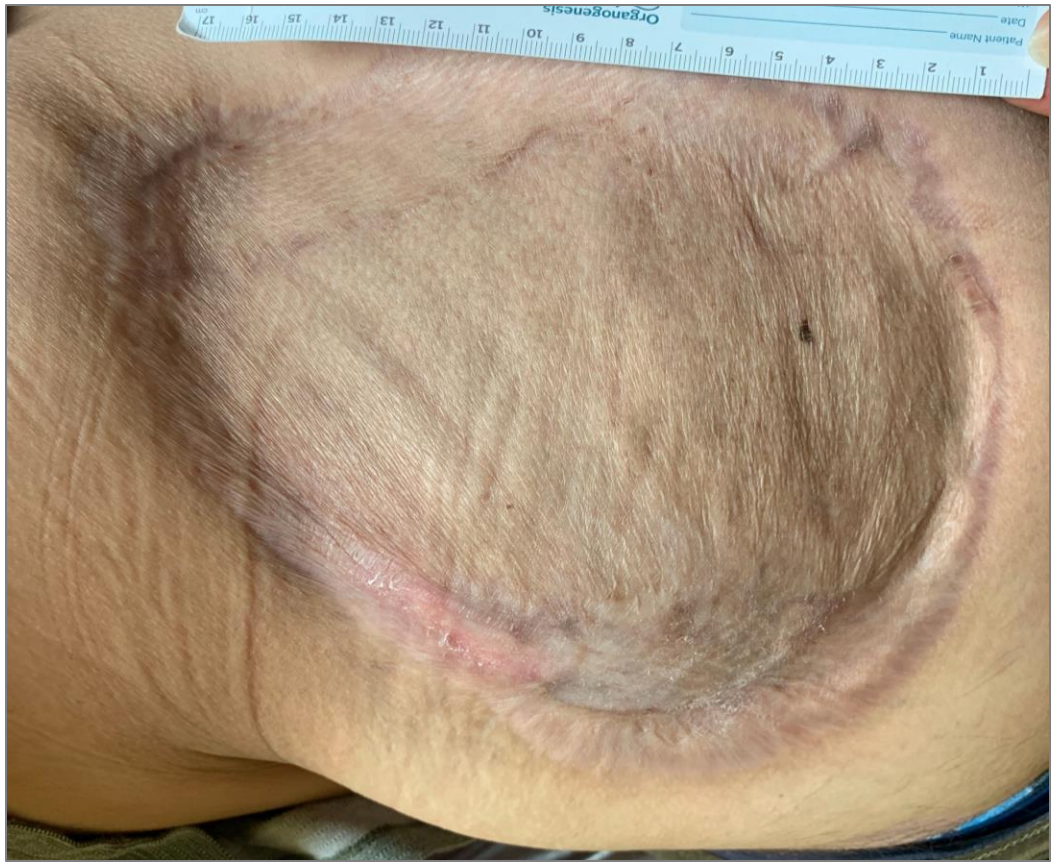
Necrotizing Soft Tissue Infections

- Aggressive serial debridement is critical
  - "3 debridements in 72 hrs"
- Optimize the patient
  - ICU care
    - Renal function
    - Fluid resuscitation vs edema
    - Ventilator support
    - Nutrition, diabetes management
- Rapidly cover
  - Decreases frequency of wound care
  - Decreases inflammatory reaction
  - Decreases pain
    - Improves overall management and ability to extubate

Post-Acute Care

- Coordinated effort with Case manager for discharge with NPWT
- Discussed with VNA and equipment rep due to insurance not covering usual NPWT device
- Virtual visits with VNA due to increased drainage:
  - Wound culture
  - Prep for grafting

From ICU to Healed and Back to Work: 6 Months



Operative Debridement → iNPWT → NPWT

Infected hematoma

Operative debridement

1 wk iNPWT

2 months post-op
Telehealth
NO in-person clinic visits needed

New and Emerging Technologies To Determine Levels of Contamination And Infection in the Wound

Terry Swanson, NP, FAWMA, FMACNP
Wound Education Research Consultancy (W.E.R.C.)
swansonterry7@gmail.com

Outline

- In addition to Dr Gould's review of techniques to identify infection
  - Clinical signs and symptoms
  - Wound culturing and specimen assessment
  - Fluorescence imaging

- Protease levels
- pH
- Blot test for biofilm
- Temperature
  - Long wave infrared thermography

Have We Advanced Since 2013?

Wounds INTERNATIONAL

Wound infection

***Wounds International's* clinical innovations section presents recent developments in wound care. This issue, we focus on innovations in wound infection.**

Wound infection and diagnostics in practice: what is emerging?

Authors (left to right): Gregory Schultz and Randall D Wolcott

Wound infection unquestionably impairs healing, but many chronic wounds do not have high levels of planktonic bacteria as measured by standard clinical microbiology laboratory culturing methods. Recent research (James et al, 2008; Phillips et al, 2010) suggests this "critical colonisation" state is due to the presence of polymicrobial biofilm communities that are highly tolerant of hosting antibodies, inflammatory cells, antibiotics, and many antiseptics.

Polymerase chain reaction (PCR)-based identification of multiple bacterial species from wound biopsies appears to be a promising technology that overcomes most of the limitations of traditional bacterial-culturing methods. Methods of utilising improved profiling bacterial and fungal species present in wounds enables customised formulations of antibiotics and other agents that target a specific spectrum of organisms. Topical treatment with personalised antimicrobial formulations appears to substantially improve the healing of complex wounds (Dowd et al, 2011).

in reducing adverse economic and health consequences, especially in the context of growing levels of antibiotic resistance (Harding et al, 2008). Unfortunately, current standard clinical microbiology tests – which are based on the 100-year-old technique of growth of bacteria on nutrient agar plates – only provide a partial profile of the planktonic bacterial and fungal species present in wounds; essentially, those microorganisms adapted to grow rapidly under specific conditions in an incubator (Dowd et al, 2008). This leads, in most situations, to the identification of only a select few of the many planktonic bacteria present in a wound.

Clearly, there is a need for better diagnostic tests to identify and measure levels of bacteria and fungi in wounds. However, such a test (diagnostic) should meet several parameters. It should be cost-effective, at least in the range of the current standard clinical microbiology tests. Results should be generated in a few hours and provide information that can be used to guide clinical decision-making. In other words, just having more complete information about the bacteria and fungi species present in wound biopsies, curettes or swabs has minimal effect, unless there is a way to use that information to guide specific treatments for that patient, which is the aim underpinning the concept of personalised medicine.

Fortunately, molecular biology technologies have been developed that can replace the standard microbiology culturing technique. It quickly became evident in the 1990s that sequencing the 16S regions of bacteria and 18S region of fungi led to levels of sensitivity and specificity

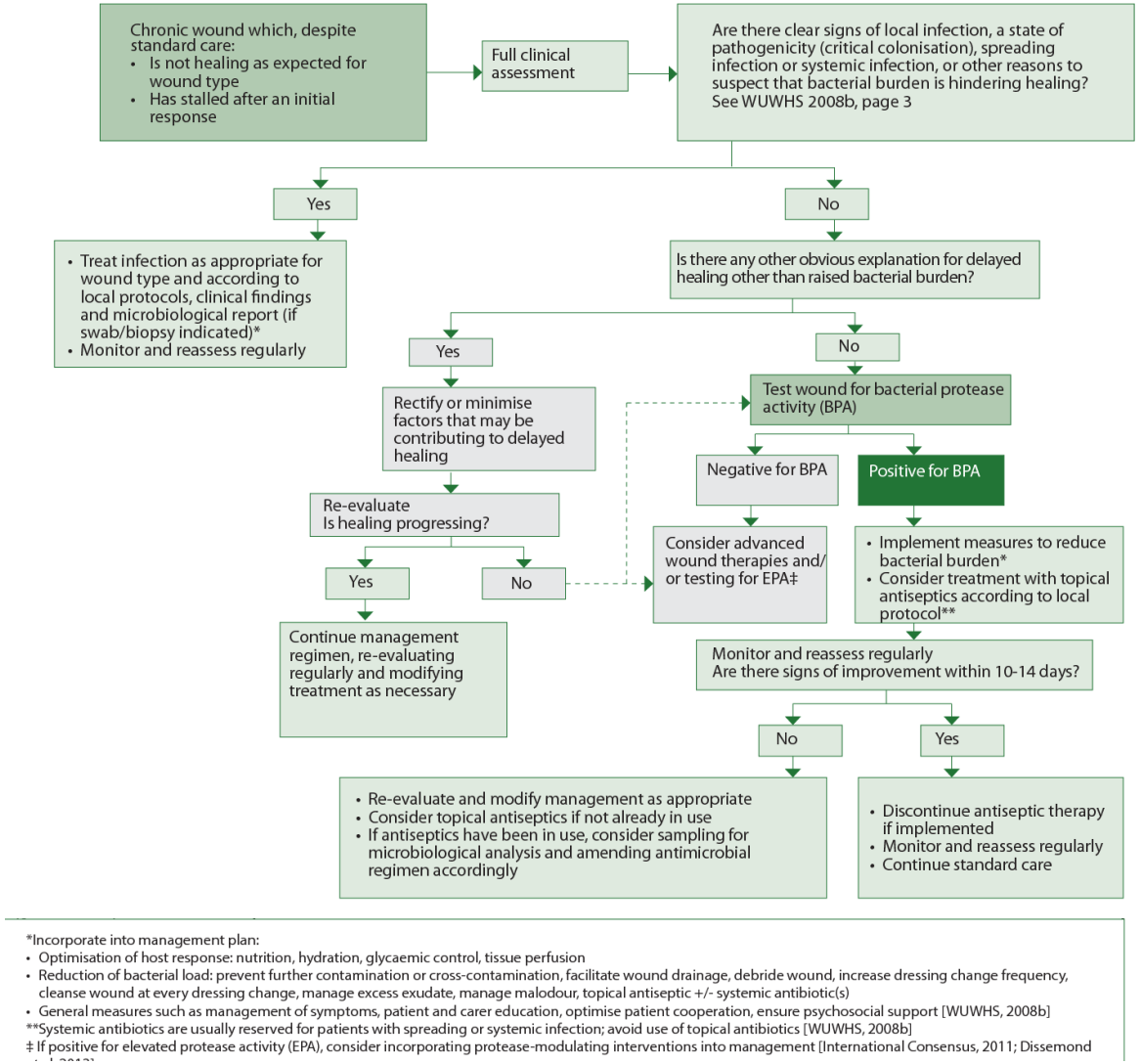
Laboratory Investigations

- C- reactive protein (CRP)
  - A protein made in the liver and increases with inflammation and infection and noted in simple blood test
  - Changes can occur within 24-48 hrs of stimulus, such as infection
  - Good correlation with acute infection such SSI and wounds exhibiting s&s of spreading infection in DFU/I
- Procalcitonin
  - Peptide hormone secreted by non-neuroendocrine parenchymal cells. Elevated in pts with bacterial infections
- White Blood Cell (WBC) count
  - Elevated WBC (leukocytosis) indicates an immune response to infection
  - Elevated neutrophils is common in bacterial infections
  - Band cells (shift to the left) indicates presence of immature WBC, which suggests the bone marrow is responding to the infection
  - Normal or low may occur in immunocompromised pts with localised infections
- Erythrocyte Sedimentation Rate (ESR)
  - Elevated during inflammation and infection, tissue injury
  - Elevation may suggest inflammation or chronic infection

Not much has changed, but when patient has signs and symptoms of spreading infection, they may be warranted

Bacterial Protease Activity (BPA)

- Elevation of proteases leads to degradation of extracellular membrane, growth factors, and receptors
- Contributes to prolonged inflammation
- May impede wound healing
- Point of Care (POC): Qualitative assessment of bacterial proteases activity amongst common bacteria in wound that correlate with pathogenicity



G Armstrong, D., Bauer, K., Bohn, G.A., Carter, M.J., Snyder, R.J., & Serena, T.E. (2020). Principles of Best Diagnostic Practice in Tissue Repair and Wound Healing: An Expert Consensus. *Diagnostics, 11*.

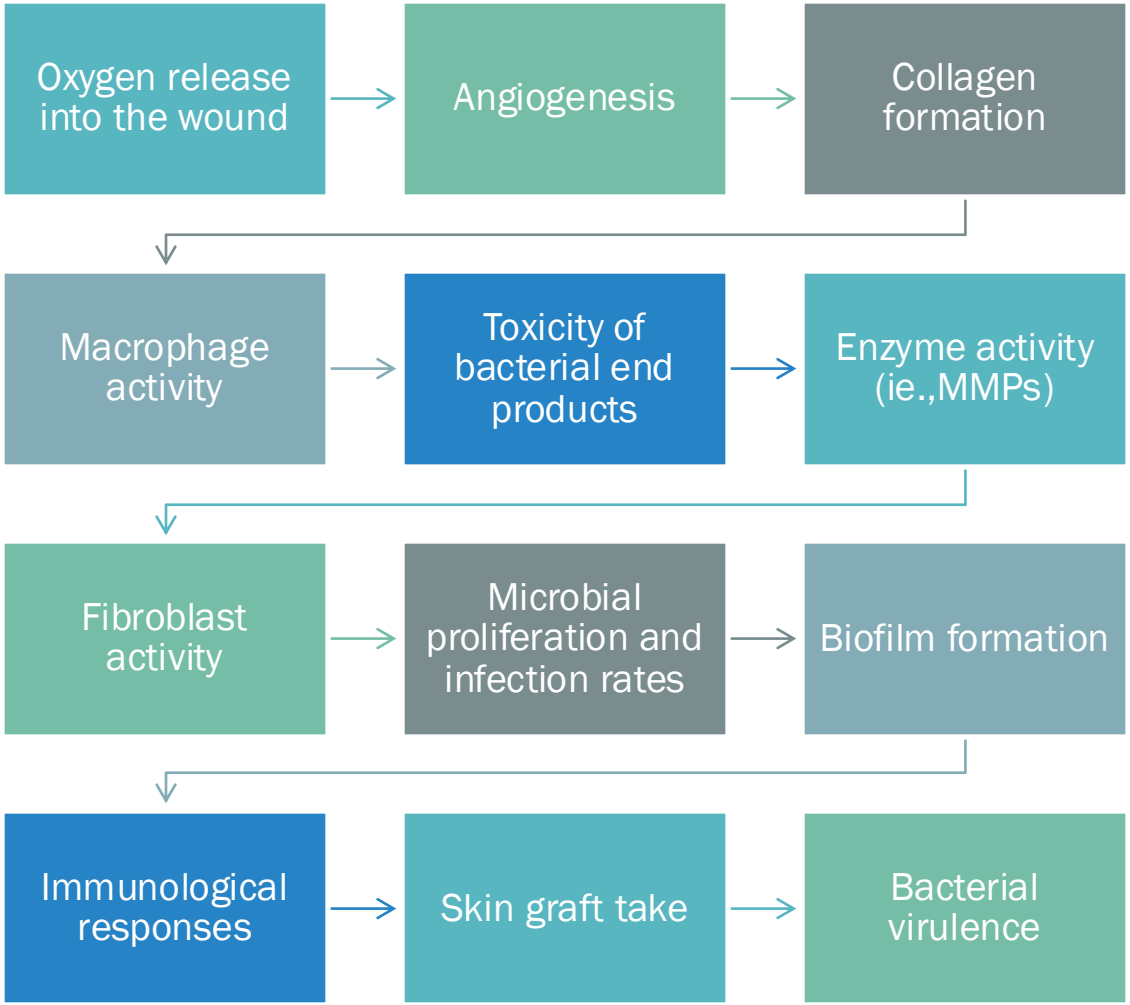
Läuchli, S., Swanson, T., Serena, T., & Harding, K.G. (2015). The use of a point-of-care test for bacterial protease activity in chronic wounds.

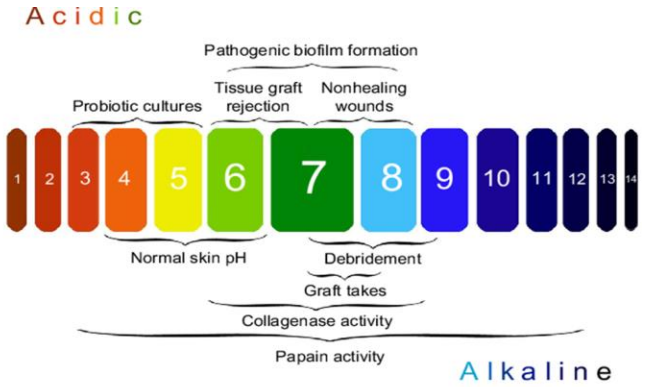
Wound pH

- Increases with bacterial colonisation
- An early indicator of infection

Kordestani SS, Mohammadi FS, Noordadi M, Rezaee F, Fayyazbakhsh F. Wound Infection Detection Using a Rapid Biomarker. Adv Skin Wound Care. 2023 Jan 1;36(1):35-40. doi: 10.1097/01.ASW.0000897448.59904.b0. PMID: 36537773.

The pH value within the wound directly and indirectly influences all biochemical reactions





Gethin G. The significance of surface pH in chronic wounds. *Wounds UK* 2007; 3: 52–6, . Olson E. Influence of pH on bacterial gene expression. *Mol Microbiol* 1993; 8: 5–14. Vestacka A, Ciznar I, Stefkovicova M. Temperature and pH affect the production of bacterial biofilm. *Folia Microbiol* (Praha) 2010; 55: 75–8, Lipsky BA, Aragón-Sánchez J, Diggle M, Embil J, Kono S, Lavery L, et al. IWGDF guidance on the diagnosis and management of foot infections in persons with diabetes. *Diabetes Metab Res Rev*. 2016;32(Suppl 1):45–74.

Why Does the pH Increase with Infection?

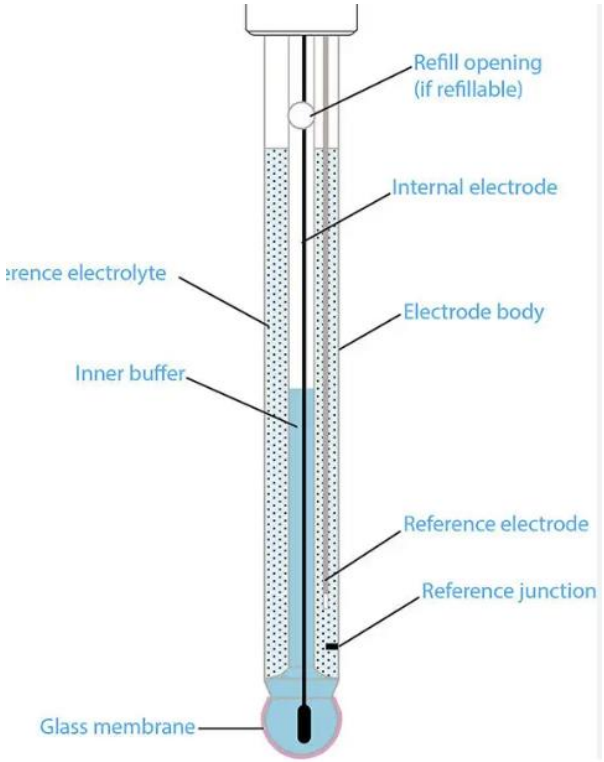
- Secretion of alkaline proteases increase the pH
- Alkaline environment allows more bacteria species to survive and multiply, as well as increased activity of gelatinases (MMP-2 – MMP-9)
- Most pathogenic bacteria are inhibited in a lower pH environment
- An increase in the pH of infected wounds may influence bacterial virulence, as well as bacterial growth
- Wound pH can also impact the effectiveness of antibiotics and antiseptics
- An alkaline environment favorable for bacterial growth

Infection Detection Using a Rapid Biomarker Soheila S. Kordestani, PhD; Fahimeh S. Mohammadi, MSc; Maryam Noordadi, MSc; Fatemeh Rezaee, MSc; and Fatemeh Fayyazbakhsh, PhD *Adv Skin Wound Care* 2023;36:35–40
Tang, N.; Zheng, Y.; Jiang, X.; Zhou, C.; Jin, H.; Jin, K.; Wu, W.; Haick, H. Wearable Sensors and Systems for Wound Healing-Related pH and Temperature Detection. *Micromachines.* 2021, 12, 430.

pH Testing – How?

When and how to test
- Before wound cleansing?

Tools to test
- Litmus paper
- Glass probe
- Digital monitors



Blotting for Biofilm

- Nakagami, et al (2017-2019) used ruthenium red or alcian blue dyes to visualise blotted biofilm on nitrocellulose membrane; although effective, it requires 30 minutes to conduct test and multiple processes
- Yu-Feng, et al (2020) modified the process to decrease time to several minutes by using alcian blue and positively charged membrane for staining plus CTAC cationic detergent for blocking and washing the membrane

Nakagami G, Schultz G, Gibson DJ, et al. Biofilm detection by wound blotting can predict slough development in pressure ulcers: a prospective observational study. *Wound Repair Regen*. 2017;25(1): 131-138. 23. Nakagami G, Schultz G, Kitamura A, et al. Rapid detection of biofilm by wound blotting following sharp debridement of chronic pressure ulcers predicts wound healing: a preliminary study. *Int Wound J*. 2019;17(1):191-196. 24. Mori Y, Nakagami G, Kitamura A, et al. Effectiveness of biofilm-based wound care system on wound healing in chronic wounds. *Wound Repair Regen*. 2019;27(5):540-547

Modified Blotting for Biofilm

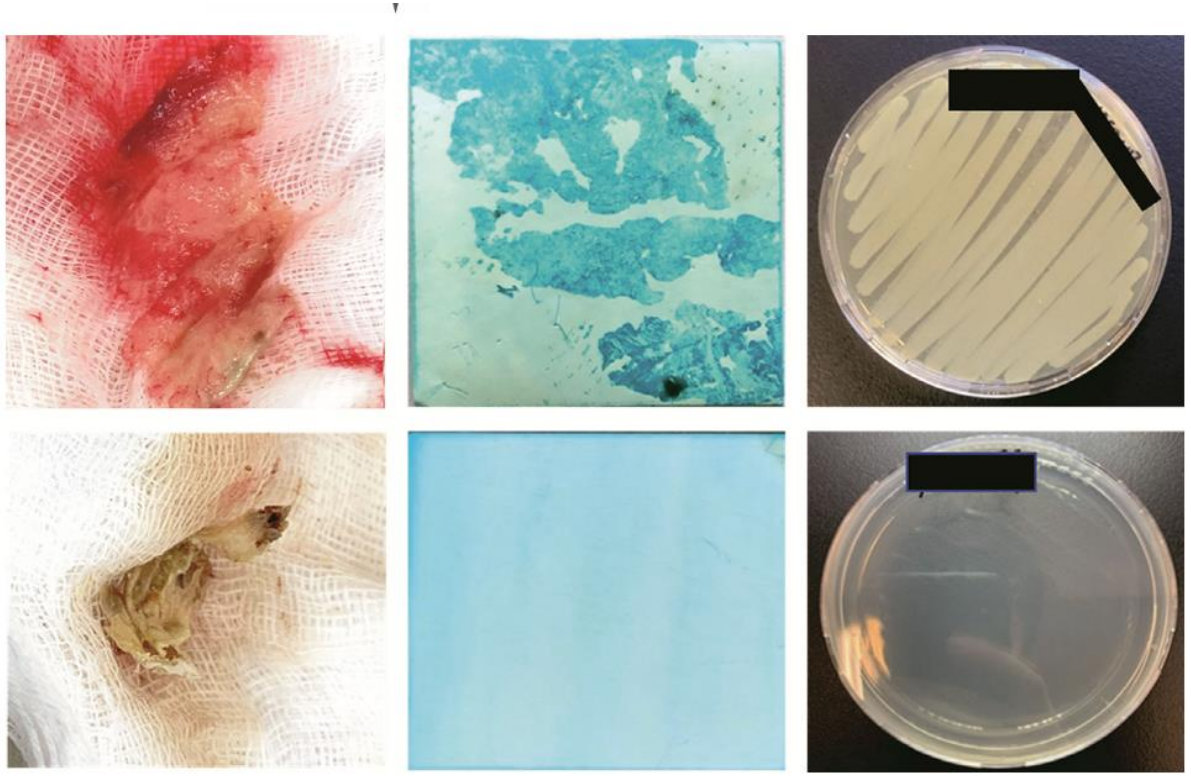


FIGURE 4 Representative cases with biofilm-positive and biofilm-negative wounds. The upper row shows a picture of clinical tissue, positive results of the modified alcian blue staining, and the positive microbiology culture of a representative biofilm-positive case. The lower row shows a picture of clinical tissue, negative results of the modified alcian blue staining, and the negative microbiology culture of a representative biofilm-negative case [Color figure can be viewed at wileyonlinelibrary.com]

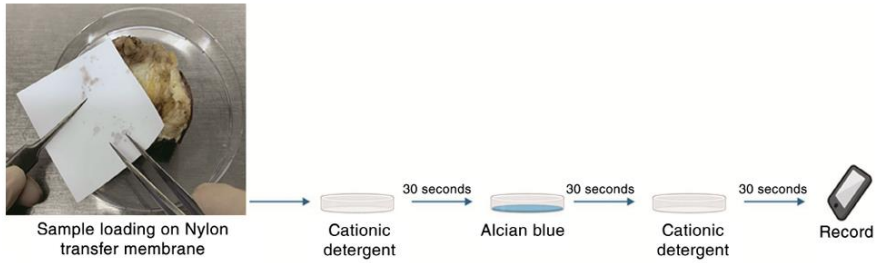
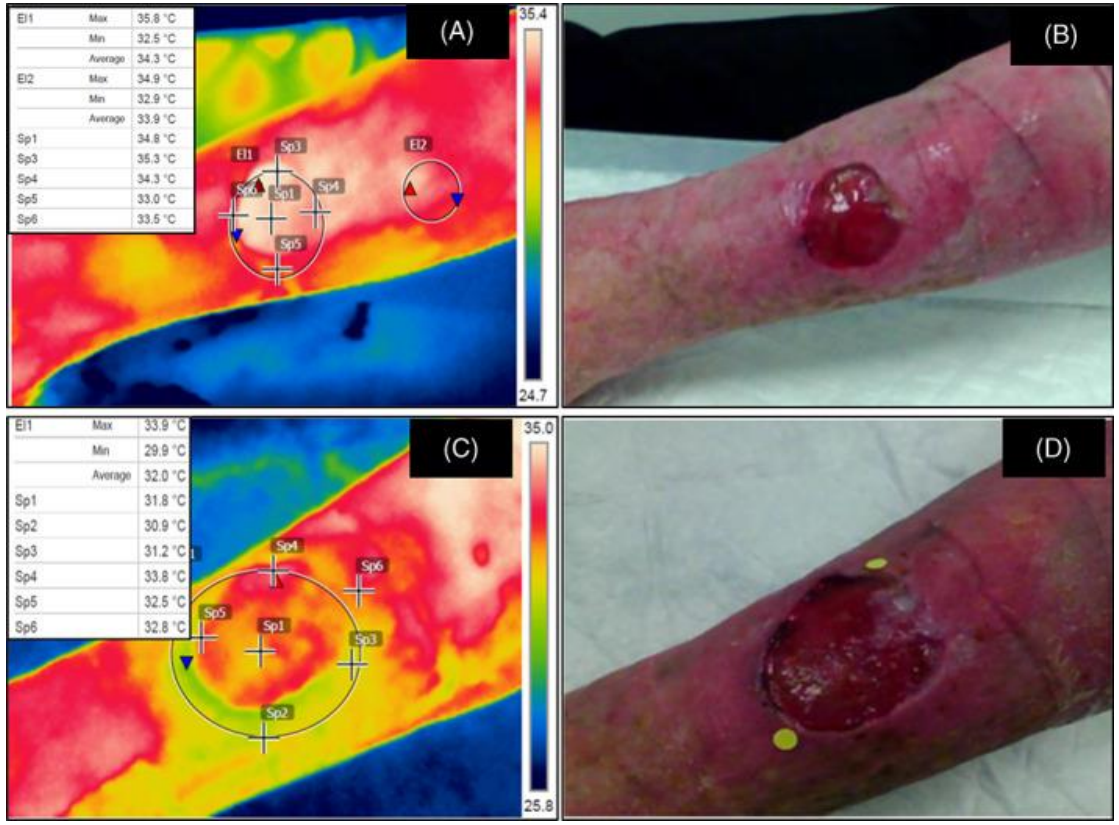


FIGURE 1 Schematic of modified alcian blue staining procedure. Sample loading by dripping 3 μL bacterial aliquots onto the membrane or pressing the membrane firmly onto wound tissue; followed by soaking the membrane in cationic detergent (30 seconds) for blocking non-specific binding, alcian blue solution for staining (30 seconds), and cationic detergent again for washing (30 seconds). The cationic detergent used in our protocol was 1% CTAC. Photographs of the air-dried (30 seconds) membranes were taken for further image processing [Color figure can be viewed at wileyonlinelibrary.com]

- Modified staining results correlated well with microbiology culturing results (83.9% consistency, 95.2% sensitivity, and 60% specificity)
- Protocol showed high predictive validity for clinical wound outcomes as determined at a 1-month follow-up visit (78.6% consistency, 83.3% sensitivity, and 70% specificity).

Wu Y, Lee T, Liao W, Chuan H, Cheng N, Cheng C. Rapid detection of biofilm with modified alcian blue staining: In-vitro protocol improvement and validation with clinical cases. *Wound Repair and Regeneration*. 2020;28(6):834-843. Accessed April 17, 2025.

Temperature



Thermography used for diagnostic, screening and monitoring purposes. An adjunctive evaluation.

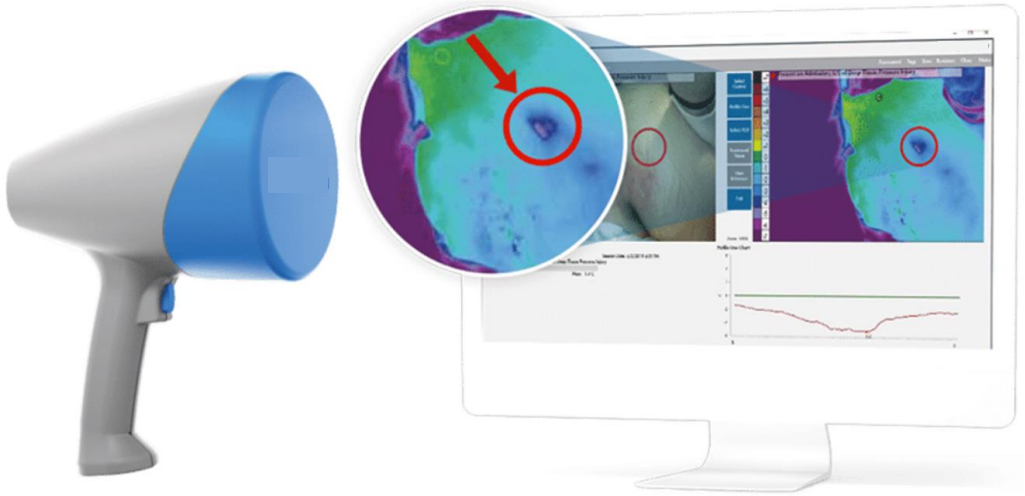
Benefits:

- Non radiation
- Simple to use
- Low cost

Derwin R, Patton D, Strapp H, Moore Z. The effect of inflammation management on pH, temperature, and bacterial burden. *Int Wound J.* 2023 Apr;20(4):1118-1129. Arts, Laure, Johan De Neve, Samira Baharlou, Nathalie Denecker, Laura Kerselaers, and Dimitri Aerden. 2022. "Assessing Diabetic Foot Infections With the ThermoScale: A Comparative Thermometry Device Designed as a Patient Self-Screening Tool." *International Journal of Lower Extremity Wounds* 21 (4): 420–24. Kesztyüs D, Brucher S, Wilson C, Kesztyüs T. Use of Infrared Thermography in Medical Diagnosis, Screening, and Disease Monitoring: A Scoping Review. *Medicina* (Kaunas). 2023 Dec 9;59(12):2139. doi: 10.3390/medicina59122139.

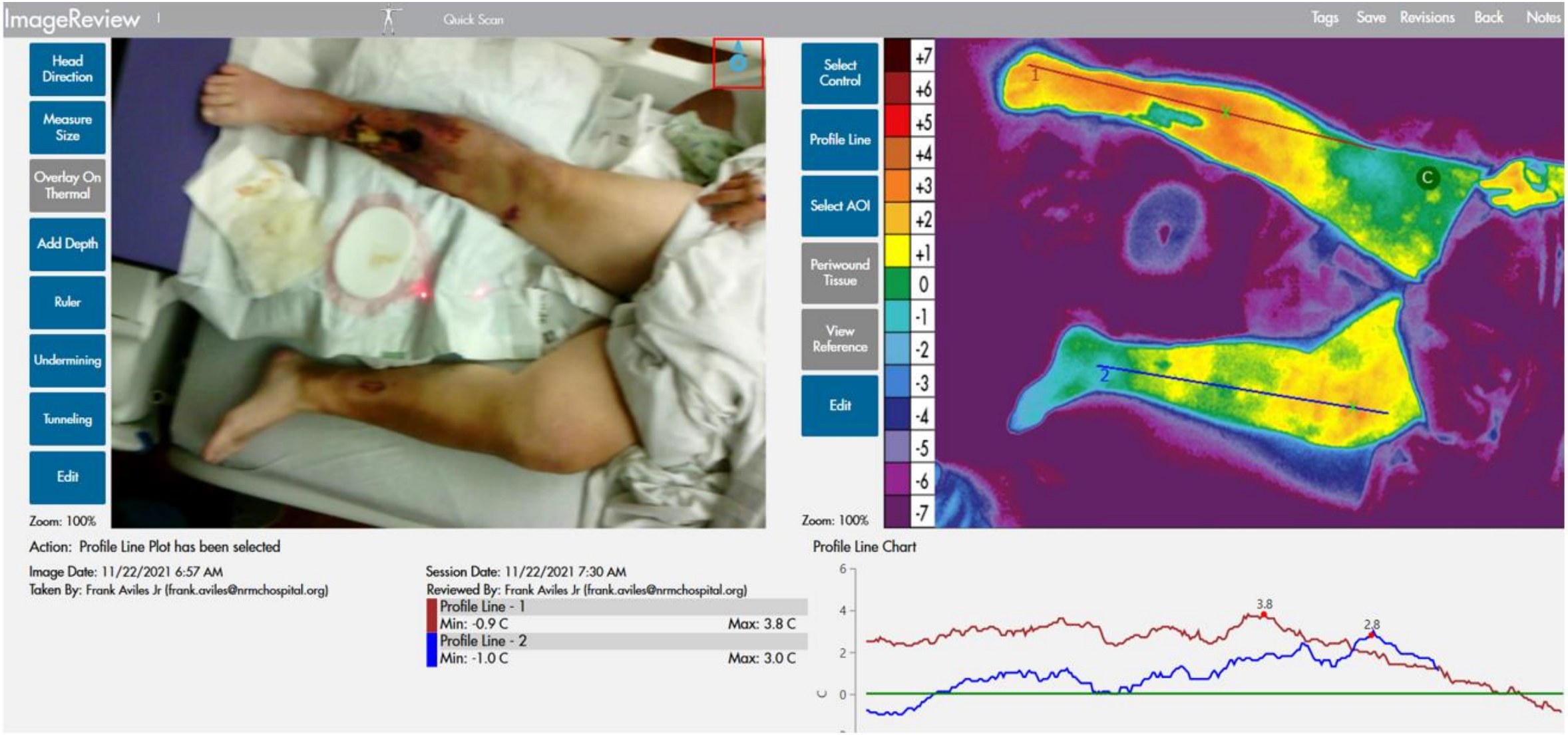
Long Wave Infrared Thermography (LWIT)

- Infrared light in the electromagnetic spectrum is nonvisible
- Measures radiation emitted from the body as thermal energy due to metabolic response to an event (like wound infection)
- Converts the information into a pattern based on temperature
- Infection/ inflammation causes hyperperfusion
- It is not a diagnostic tool but a complimentary device to aid the clinician in validating their assessment, as a preventative device, validates interventions, and guides treatments



Slides/images courtesy Frank Aviles, PT, CWS, FACCWS, CLT-LANA, ALM, AWCC, MAPWCA

LWIT: Infection Confirmed with Objective Tests



Increased metabolic activity noted by increased thermal energy beyond normal. Objective testing demonstrated a necrotizing infection

Slides/images courtesy Frank Aviles, PT, CWS, FACCWS, CLT-LANA, ALM, AWCC, MAPWCA

LWIT Validating Treatment Interventions

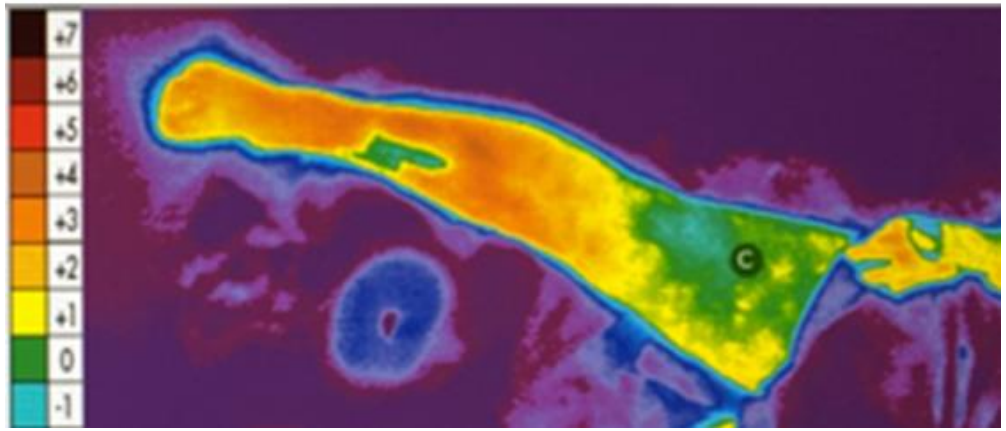
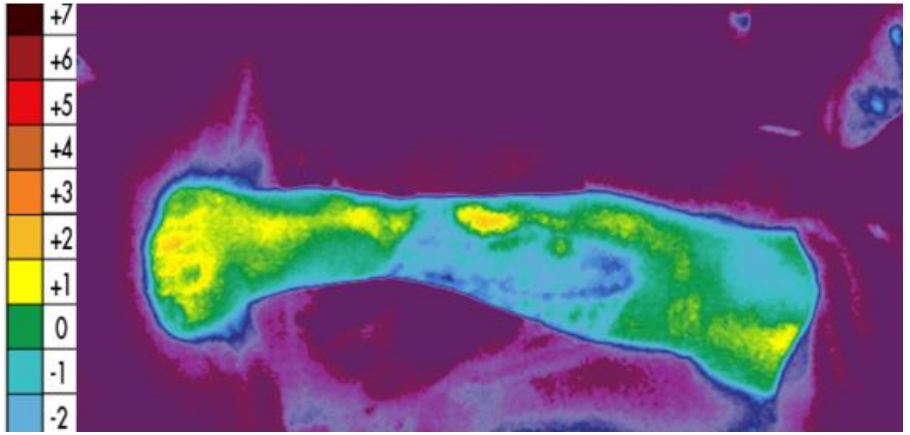


Image on Post Op Day 3



Patient was taken to surgery for extensive debridement, received hyperbaric oxygen and systemic antibiotics

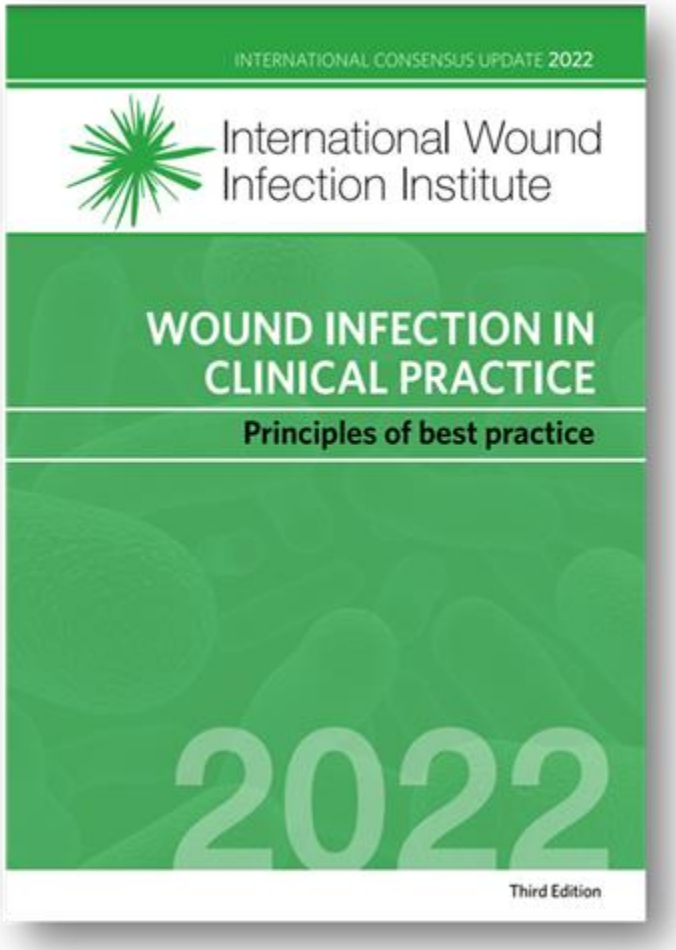
Slides/images courtesy Frank Aviles, PT, CWS, FACCWS, CLT-LANA, ALM, AWCC, MAPWCA

Therapeutic Wound and Skin Cleansing: Clinical evidence and recommendations from the IWII

Terry Swanson, NP, FAWMA, FMACNP
Wound Education Research Consultancy (W.E.R.C.)
swansonterry7@gmail.com

Overview

- Wound Infection Continuum (IWII)
- Therapeutic Wound and Skin Cleansing
  - Patient/Wound/Environment
  - WIC
  - Solutions
  - Techniques
  - Intensity
  - Equipment
- Three zones for cleansing
- Solutions and considerations
- Pain considerations
- Aseptic Technique
- Wound and Skin Cleansing Continuum (IWII)



IWII WOUND INFECTION CONTINUUM

INTERNATIONAL WOUND INFECTION INSTITUTE

Increasing microbial burden in the wound

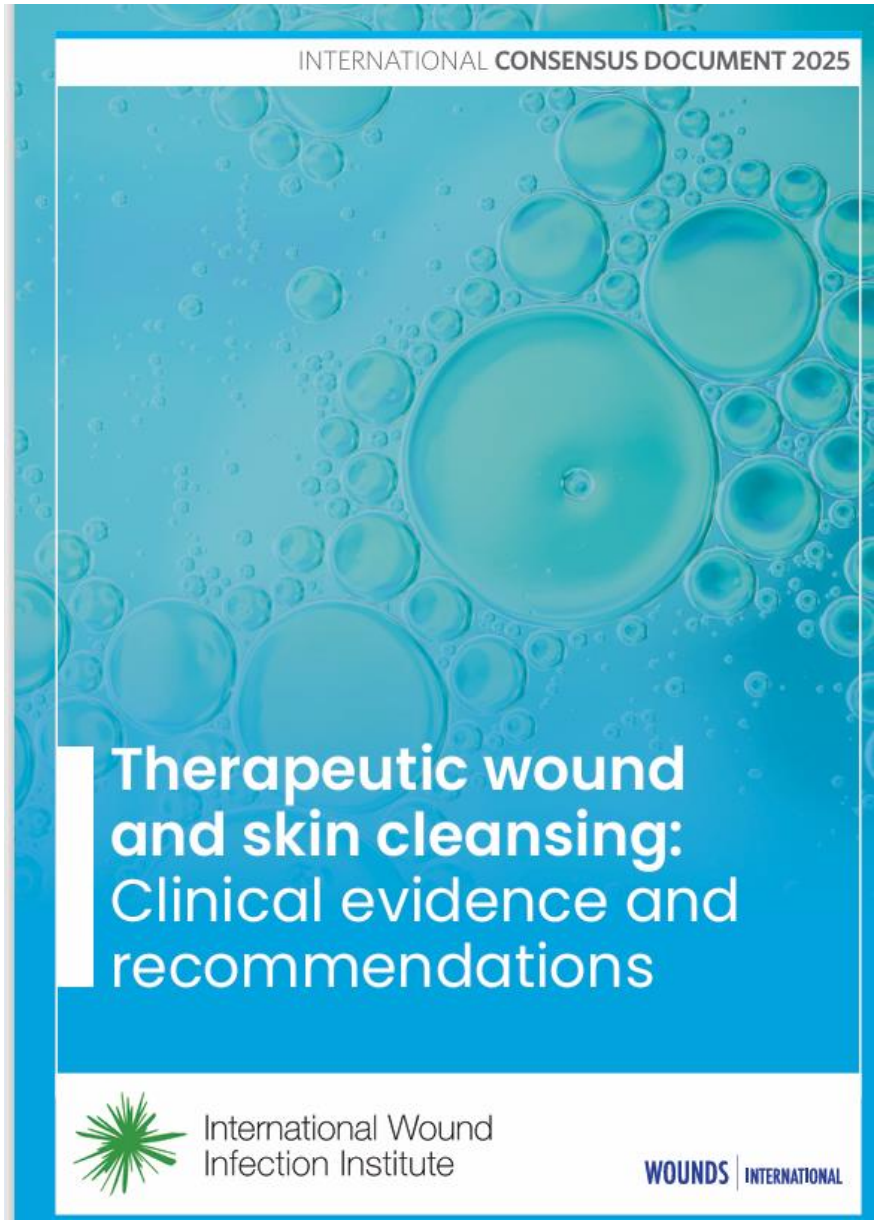
As the continuum green shading darkens, microbial burden increases

CONTAMINATION	COLONISATION	LOCAL WOUND INFECTION		SPREADING INFECTION	SYSTEMIC INFECTION
		COVERT (subtle)	OVERT (classic)		
• Microorganisms are present within the wound but are not proliferating • No significant host reaction is evoked • No delay in healing is clinically observed	• Microorganisms are present and undergoing limited proliferiation • No significant host reaction is evoked • No delay in wound healing is clinically observed	• Hypergranulation • Bleeding, friable granulation • Epithelial bridging and pocketing in granulation tissue • Increasing exudate • Delayed wound healing beyond expectations	• Erythema • Local warmth • Swelling • Purulent discharge • Wound breakdown and enlargement • New or increasing pain • Increasing malodour	• Extending induration • Spreading erythema • Inflammation or erythema >2cm from wound edge • Crepitus • Wound breakdown/ dehiscence with or without satellite lesions • Lymphangitis (swelling of lymph glands)	• Malaise • Lethargy or nonspecific general deterioration • Loss of appetite • Fever/pyrexia • Severe sepsis • Septic shock • Organ failure • Death

Wound Cleansing / Debridement and Commence antimicrobials

Plus Antibiotics

https://www.woundinfection-institute.com



https://www.woundinfection-institute.com

IWII THERAPEUTIC WOUND AND SKIN CLEANSING CONTINUUM

INTERNATIONAL WOUND INFECTION INSTITUTE

- Three zones for therapeutic cleansing: wound bed and edge, periwound and surrounding skin
- Apply antiseptics for the recommended contact time to achieve antimicrobial activity
- Follow local policies and procedures

Increasing microbial burden in the wound

As the continuum green shading darkens, microbial burden increases

	HEALING	CONTAMINATION	COLONISATION	LOCAL WOUND INFECTION COVERT (subtle)	LOCAL WOUND INFECTION OVERT (classic)	SPREADING INFECTION	SYSTEMIC INFECTION
		• Microorganisms are present within the wound but are not proliferating • No significant host reaction is evoked • No delay in healing is clinically observed	• Microorganisms are present and undergoing limited proliferation • No significant host reaction is evoked • No delay in wound healing is clinically observed	• Hypergranulation • Bleeding, friable granulation • Epithelial bridging and pocketing in granulation tissue • Increasing exudate • Delayed wound healing beyond expectations	• Erythema • Local warmth • Swelling • Purulent discharge • Wound breakdown and enlargement • New or increasing pain • Increasing malodour	• Extending induration • Spreading erythema • Inflammation or erythema >2cm from wound edge • Crepitus • Wound breakdown/ dehiscence with or without satellite lesions • Lymphangitis (swelling of lymph glands)	• Malaise • Lethargy or nonspecific general deterioration • Loss of appetite • Fever/pyrexia • Severe sepsis • Septic shock • Organ failure • Death
PAIN	• Continual pain assessment: Remember the 3 As of pain management: Anticipate, Administer and Assess						
WOUND CLEANSING SOLUTION	• Inert solutions	• Inert solutions	• Inert solutions • High risk: surfactants and/or antiseptics	• Antiseptics • Surfactants • Inert solutions		• Antiseptics • Surfactants • Inert solutions	
WOUND CLEANSING INTENSITY	• Gentle	• Gentle to moderate	• Moderate/ rigorous	• Moderate to vigorous		• Vigorous	
WOUND CLEANSING TECHNIQUE	• Therapeutic cleansing • Irrigation • Soaks	• Therapeutic cleansing • Irrigation • Soaks • Compress • Swabbing • Scrubbing/mechanical action • Instillation • Hydroresponsive dressings					
CLEANSING EQUIPMENT	• Cleansing wipes/cloth • Irrigation equipment • Cleansing pad/microfilament pad • Gauze						
SKIN CLEANSING	• Mild skin cleanser with pH close to normal skin (4 to 5.5) • Cleansing wipes/cloths/gauze • Soaks, swabbing, scrubbing/mechanical action						

Figure 5. International Wound Infection Institute (IWII) Therapeutic Wound and Skin Cleansing Continuum

Why a stand-alone document on cleansing?

- Lack of terminology/definitions
- Confusion regarding
  - How
  - When
  - What to use
  - How to use it

Definition of Therapeutic Wound Cleansing

TWC refers to the active removal of surface contaminants, loose debris, non-attached, non -viable tissue, microorganisms and / or remnants of previous dressings from the wound bed and periwound.

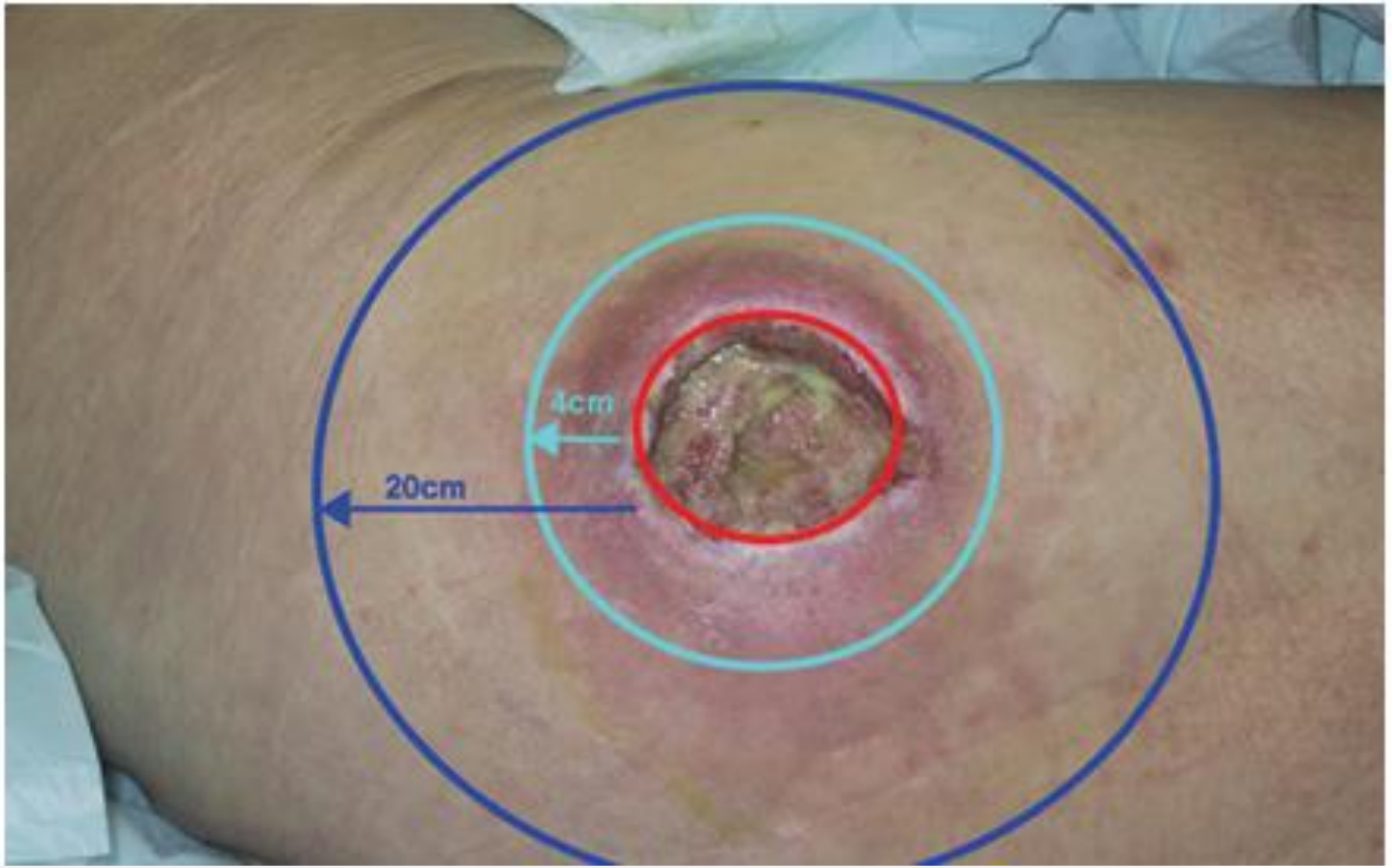
"Stop anointing wounds" Terry Swanson
"Clean it like you mean it" Dot Weir

Figure 2. Therapeutic cleansing zones

Zone 1 (red): wound bed and wound edge

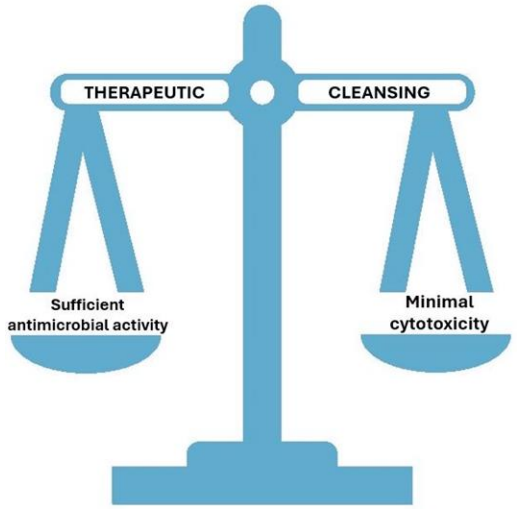
Zone 2 (light blue): periwound 4cm from wound edge

Zone 3 (blue): surrounding skin zone 20cm from wound edge



The Three Zones for Cleansing

Considerations when selecting a wound cleansing solution



Wound dressing procedure and therapeutic cleansing technique	• sterile/surgical aseptic technique → sterile solution must be selected • volume of cleanser needed • feasible for the cleansing application technique
Wound characteristics	• Healthy granulation and epithelial tissue is predominant → inert solution • sloughy, necrotic or stagnant wound bed →surfactants and antimicrobial cleaners (EXCEPTION: dry necrotic tissue on heels should be kept dry)
Risk/presence of infection	• individual at higher wound infection risk → antiseptic solution • infection suspected based →antiseptic solution • infection confirmed through diagnostic testing → antiseptic solution
Abundance/ species of microorganisms	• Infection suspected → antiseptic with broad antimicrobial properties • Infection confirmed →antiseptic solution with known activity against the species
Cytotoxicity and allergenicity	• Check the individual's allergies • Therapeutic index can be used as an indication of the balance between safety and clinical effectiveness • Balance the toxicity profile with the benefits in promoting healing
Optimal pH	• Monitor the wound bed pH • Use antiseptics strategically to optimise wound bed pH
Goals of care / individual factors	• Consider care goal (e.g. healing, prevent infection, or palliative) • Palliative management with no signs/symptoms concerning individual → non-sterile solution • Purulent exudate and/or malodour → antiseptic solution • If pain occurs on application, review selection. • Time constraints
Product information	• Review product information for the recommended contact time with the wound • Review product information for any safety considerations
Local policies, resources and availability	• Available in dispensary and/or can be acquired? • Cost and resources required • Microbial stewardship guidelines

Cleansing solution*	Properties	Concentration	pH	Therapeutic index**	Safety profile#	Mode of Action

*There are multiple different preparations available for most cleansing solutions. Data is indicative only, always read the product information.

**The therapeutic index is a ratio of the lowest concentration that causes cytotoxicity to human cells over the minimum bactericidal concentration. A high therapeutic index indicates the wound cleanser is safe and has potential greater clinical effectiveness.[69]

Always review the manufacturer's information regarding safe product use.

Table 3: Profiles of commonly used wound and skin cleansing solutions

Therapeutic Index

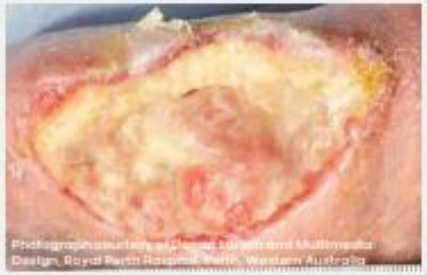
The therapeutic index is a ratio of the lowest concentration that causes cytotoxicity to human cells over the minimum bactericidal concentration.

A high therapeutic index indicates the wound cleanser is safer and has potential greater clinical effectiveness, noting the data is from *in vitro* studies.

Partial Table 3: Profiles of commonly used wound and skin cleansing solutions

Cleansing solution*	Properties	Concentration	pH	Therapeutic index**	Safety profile#	Mode of Action
**There are multiple different preparations available for most cleansing solutions. Data is indicative only, always read the product information.*						
*** The therapeutic index is a ratio of the lowest concentration that causes cytotoxicity to human cells over the minimum bactericidal concentration. A high therapeutic index indicates the wound cleanser is safer and has potential greater clinical effectiveness.* [69]						
#Always review the manufacturer's information regarding safe product use.						
Acetic Acid	Antimicrobial	1% –5% (3% conc. should be preferred)	2.4	No data	Cytotoxicity to human cells is reported at concentrations as low as 0.25% [83] Allergic reaction is rare [84]	• Passively diffuses into bacterial cells, resulting in anion accumulation and osmotic alternations that impair metabolic processes. [85]
Aluminium acetate	Antimicrobial Astringent	13% aluminium acetate dissolved in water at 1:40 concentration [86]	3–4.5	No data	• May cause hypersensitivity [87] • Not recommended under an occlusive dressing [87]	• High acidity causes deformations on the bacterial cell wall and cytoplasm [88] • Astringent properties that cause contraction of cells, reducing inflammation • Drying action reduces maceration in skin folds
Betaine and Poly-hexamethylene biguanide (PHMB)	Surfactant (betaine) Antimicrobial (PHMB)	0.1%	6–8	Mean therapeutic indices: [89] MRSA 12.12 *Paeruginosa* 1.14 *E.coli* 0.66 *S.aureus* 0.60	• Minimal cytotoxicity is reported [89,29,90] • Potential for allergic reaction is low [91]	• Polyhexanide increases bacterial membrane permeability and disrupts adenosine triphosphate (ATP) production, [77,92] interferes with bacterial production of homoserine and interferes with quorum sensing ability [28] • Betaine reduces the adherence quality of microbials, reducing the force required to remove bacteria and debris [76,77]
Chlorehexidine	Antimicrobial	0.05%	5.5-7	Mean therapeutic indices: [89] MRSA 2.43 *Paeruginosa* 0.70 *E.coli* 1.15 *S.aureus* 0.07	• Cytotoxicity reported [89,29] • Reported to damage granulating tissue [93] • Hypersensitivity reported [94,95]	• Binds to bacterial cell wall, interfering with the metabolic capacity of the cell, interferes with the cell membrane integrity causing leakage of cellular material from the bacteria [96] • Tolerance and resistance has been reported in gram-negative and gram-positive bacterial species [93,96]
Citric acid	Antimicrobial Used in other preparations to adjust pH	3%	3–6	No data		• Disrupts the bacterial cell membrane and lowers the pH, slowing bacterial growth [97] • Alters bacterial metabolic activity [97]
Gentle soap	Surfactant	No data	7	No data	No cytotoxicity in humans reported [98]	• May stimulate autolytic debridement and reduce inflammation by degrading collagen and influencing protein activity. [74] • Reduces the adherence quality of microbials, reducing the force required to remove bacteria and debris [76,77]
Hypochlorous acid (HOCl)	Antimicrobial Hypotonic	0.03%	3.5–5.5	Mean therapeutic indices: [89] *Paeruginosa* 8.81 *S.aureus* 6.31 *E.coli* 5.49	No cytotoxicity [4]	• Passively diffuses into bacterial cells, leading to anion accumulation and osmotic alternations that impair metabolic processes. [99] • Oxidizes the surfaces of bacterial cells to disrupt membrane function and softens tissue, aiding its removal during cleansing and debridement. [92,100,101] • Has an anti-inflammatory effect through reducing activity of histamines, MMPs, mast cell and cytokine activity [92,100]
Normal saline (NaCl)	Isotonic	0.9%	5.5	No data	Allergic reaction rare [84]	• Exact mechanism of normal saline is not known. • At high concentrations, saline disrupts bacteria through osmotic alternations.14
Octenidine Dihydrochloride (OCT)	Antimicrobial Surfactant Cationic	0.5%	1.6–12.2	Mean therapeutic indices: [89] *E.coli* 1.33 *P.aeruginosa* 0.95 *S.aureus* 1.15 MRSA 3.33	Allergic reaction rare [84]	• Disrupts outer cell membrane and loss of cell wall and bind to bacteria leading to cell death • Has anti-inflammatory effects [4]

Wound bed tissue appearance: Part 1

Wound bed tissue	Appearance	
Non-viable adipose tissue	Non-viable body fat and loose connective tissue that appears white, brown or yellow (colour varies by hydration). It may resemble fat molecules or droplets and can sometimes be mistaken for slough	 
Epithelial tissue	Pink, lavender or pearly white in appearance, indicating the wound is viable and healthy. Note that epithelialisation will not occur in an unhealthy wound bed	 
Granulating tissue	Red, moist and well-vascularised, occurring during the reconstruction (proliferative) phase of healing and indicates the wound bed is viable and healthy	 
Slough	Adherent tissue that appears yellow, brown or grey and indicates presence of devitalised tissue (i.e. dead cells) and debris that will impede wound healing	 

Wound Infection Continuum

Solution

Intensity

- Gentle
- Moderate
- Rigorous
- Vigorous

Technique

Equipment

IWII THERAPEUTIC WOUND AND SKIN CLEANSING CONTINUUM

INTERNATIONAL WOUND INFECTION INSTITUTE

- Three zones for therapeutic cleansing: wound bed and edge, periwound and surrounding skin
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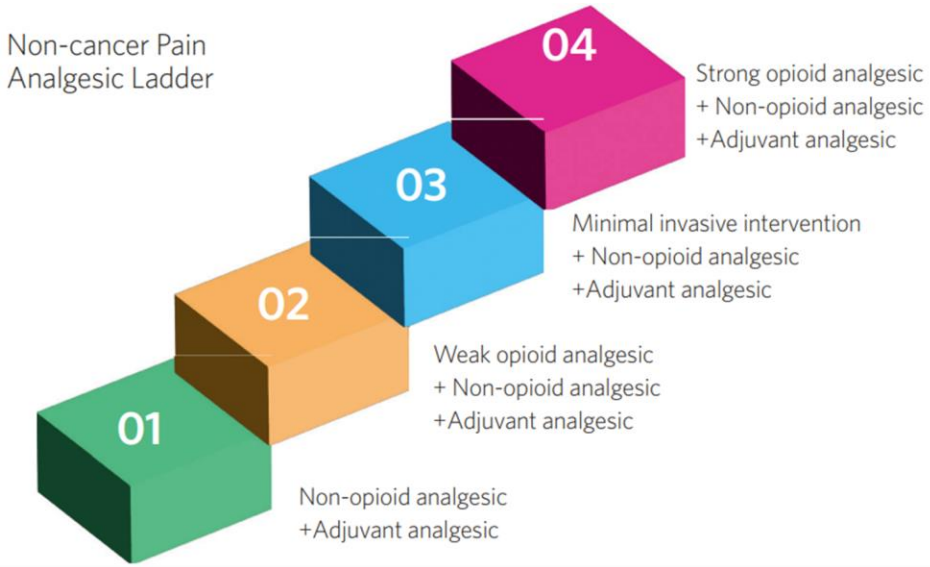
Overview of wound cleansing techniques

Technique	When to use
Irrigation/ flushing	• minimal exudate • without slough • minimal microbial burden
Swabbing	• exudate • visible debris, slough and other nonviable tissue • signs and symptoms of infection
Scrubbing/ cleansing pad/ monofilament fibre pad/ gauze pad	• exudate • visible debris, slough and other nonviable tissue • signs and symptoms of infection
Compress	• Heathy granulation or new epithelialisation with healthy or dry wound edges • Wet wound bed with macerated wound edges • loose debris or signs and symptoms of local wound infection
Soaking/bathing/ wet packing	• require increased hydration/moisture (e.g. dry healable wounds or moisture-balanced wound bed with desiccated wound edges) • Signs and symptoms of local wound infection and spreading infection • visible debris • Surrounding skin or periwound with visible debris or hyperkeratotic tissue
Instillation	• small debris particles that are more difficult to dislodge, • poor wound bed integrity • need for grafting or granulation tissue formation
Hydro-responsive dressings	• devitalised tissue requiring removal • dry or moist wound bed

Addressing Pain Associated With Therapeutic Wound Cleansing



Updated non-cancer pain analgesic ladder (Yang et al 2020, Anekar et al, 2023)

3 As of pain

- Anticipate
- Administer
- Assess

Strategies for pain

- Topical and systemic analgesia
- Warm solutions
- Education and explanation
- Appropriate technique

Summary

- Take the time to be therapeutic
- Three zones for cleansing
- Use solutions appropriately for good antimicrobial stewardship
- Proactive care to promote healing

IWII Expert Working Group

- Terry Swanson (Australia)
- Geoff Sussman (Australia)
- Dot Weir (USA)
- Donna Larsen (Australia)
- Karen Ousey (UK)
- Emily Haesler (Australia)
- Keryln Carville (Australia)
- Trish Idensohn (South Africa)
- Steven Percival (UK)
- Susie Seaman (USA)
- Kim LeBlanc (Canada)
- Hari Nair (Malaysia)
- Nicola Waters (Canada)
- David Keast (Canada)
- Paulo Alves (Portugal)

Reviewers: Prof Thomas Bjarnsholt and Prof Lindsey Kalan

IWII Has Free Membership
https://woundinfection-institute.com

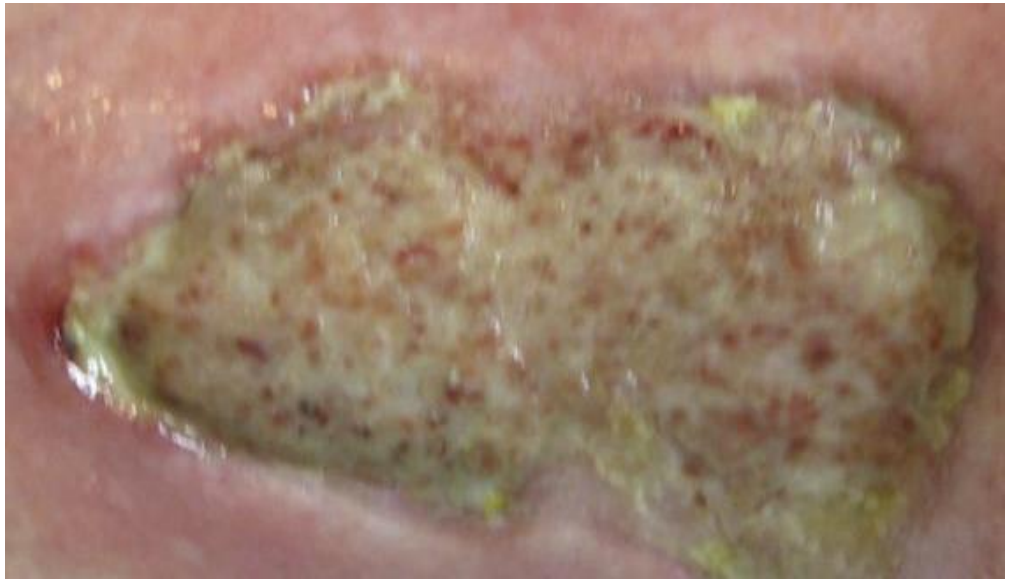
International Wound Infection Institute

Slough Removal and Infection Control

Terry Swanson, NP, FAWMA, FMACNP
Wound Education Research Consultancy (W.E.R.C.)
swansonterry7@gmail.com

Outline

- Definition
- Identification of the yellow
- IWII Slough Project and results
- Management of slough



Slough: Composition, Analysis, and Effect on Healing

https://www.woundinfection-institute.com

Slough

- Non-viable tissue of varying colour (eg, cream, yellow, greyish or tan) that may be loose or firmly attached, slimy, stringy, or fibrinous
- Varies in colour, moisture, consistency, and adherence

Types of and colour of nonviable tissue

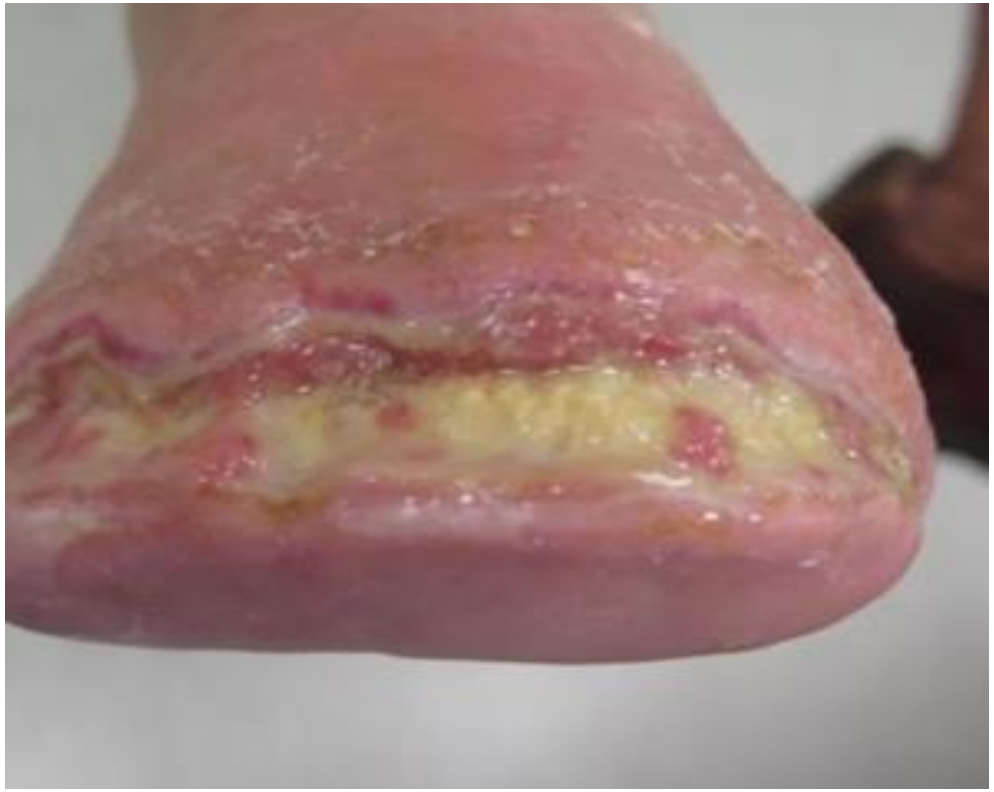
Colour	Moisture content (range)	Consistency	Adherence to wound bed
Cream/yellow	Moist or wet	'Mucinous'/slimy soft	Non-adherent
		'Gelatinous' soft	Loosely adhered
Tan/brown			Firmly adhered
Grey/blue May be seen with topical application of some silver antimicrobial dressings		Stringy/clumpy firm	Separating edges
Green May be seen in the presence of Pseudomonas aeruginosa – local infection		Fibrinous firm to hard	
Black (in addition to full-thickness NVT) May also be seen in the presence of specific bacterial local infection		'Leathery' hard	
	Dry and dehydrated		

White W & Asimus M, (in print) Assessment and management of non-viable tissue. Chapter 8 in Swanson T, Asimus M, McGuiness W. Wound Management for the Advanced Practitioner. PI Communications . Used with permission

Haesler E, Swanson T, Ousey K. (2022) Establishing a consensus on wound infection definitions. JWC 31(12):548-559

Slough and Its Detrimental Effects

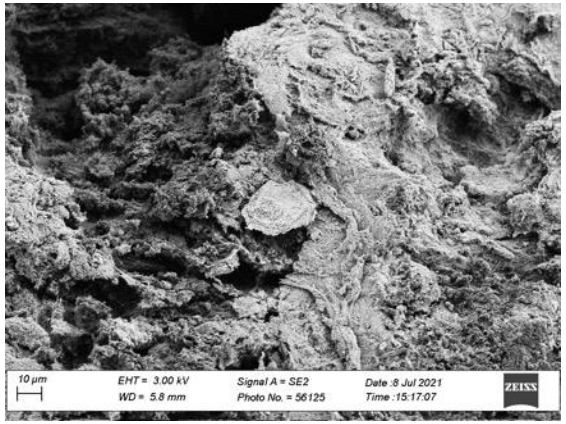
- Known feature of non-healing wounds
- Can promote bacterial growth and biofilm formation
- Barrier to topical management
- Prevent formation of granulation tissue and subsequent re-epithelialisation
- Interferes with wound contraction



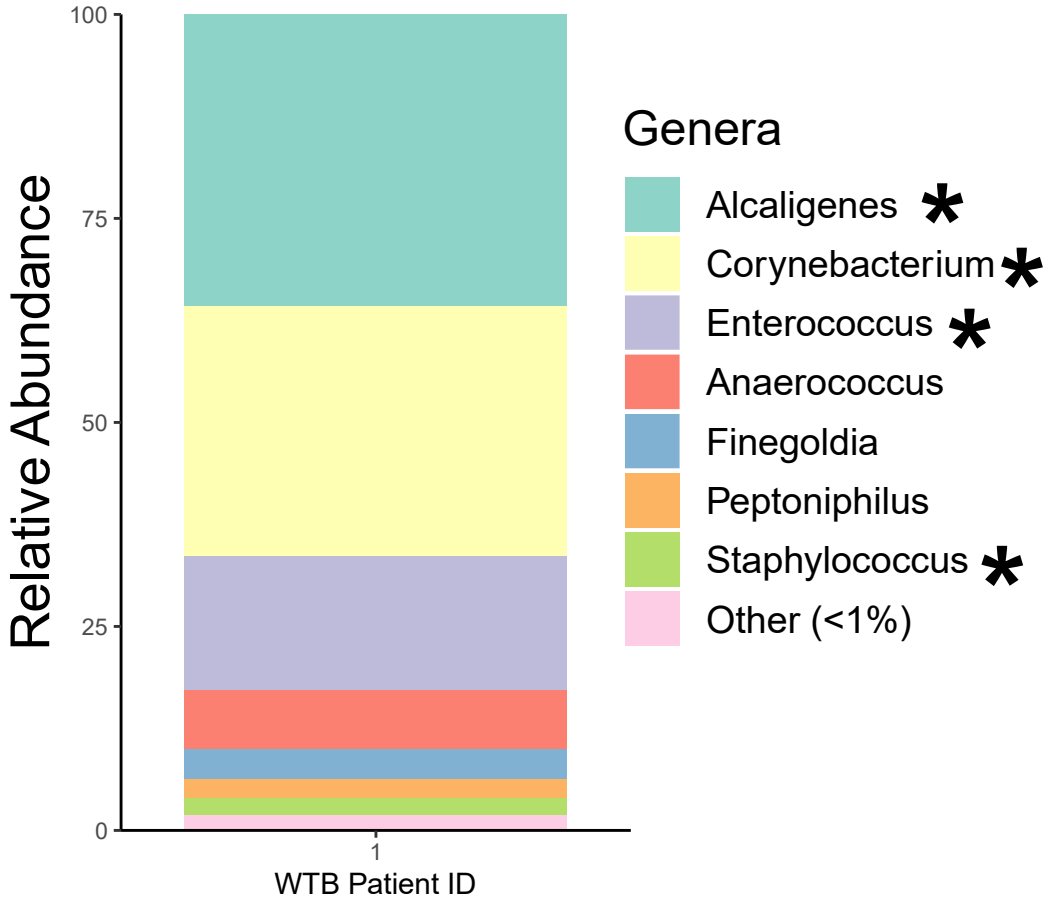
Kalan L, Schultz G, Malone MKalan L, Schultz G, Malone M et al (2023) Slough: Composition, analysis and effect on healing. Wounds International / International Wound Infection Institute.

Patient A

Side	Location	Etiology	Age	Length(cm)	Width(cm)	cm^2	Shape	CFUs
Left	Medial Ankle	Lymphedema	15	8.5	4	34	Irregular; Round Oval	**1.3 x 10^7**

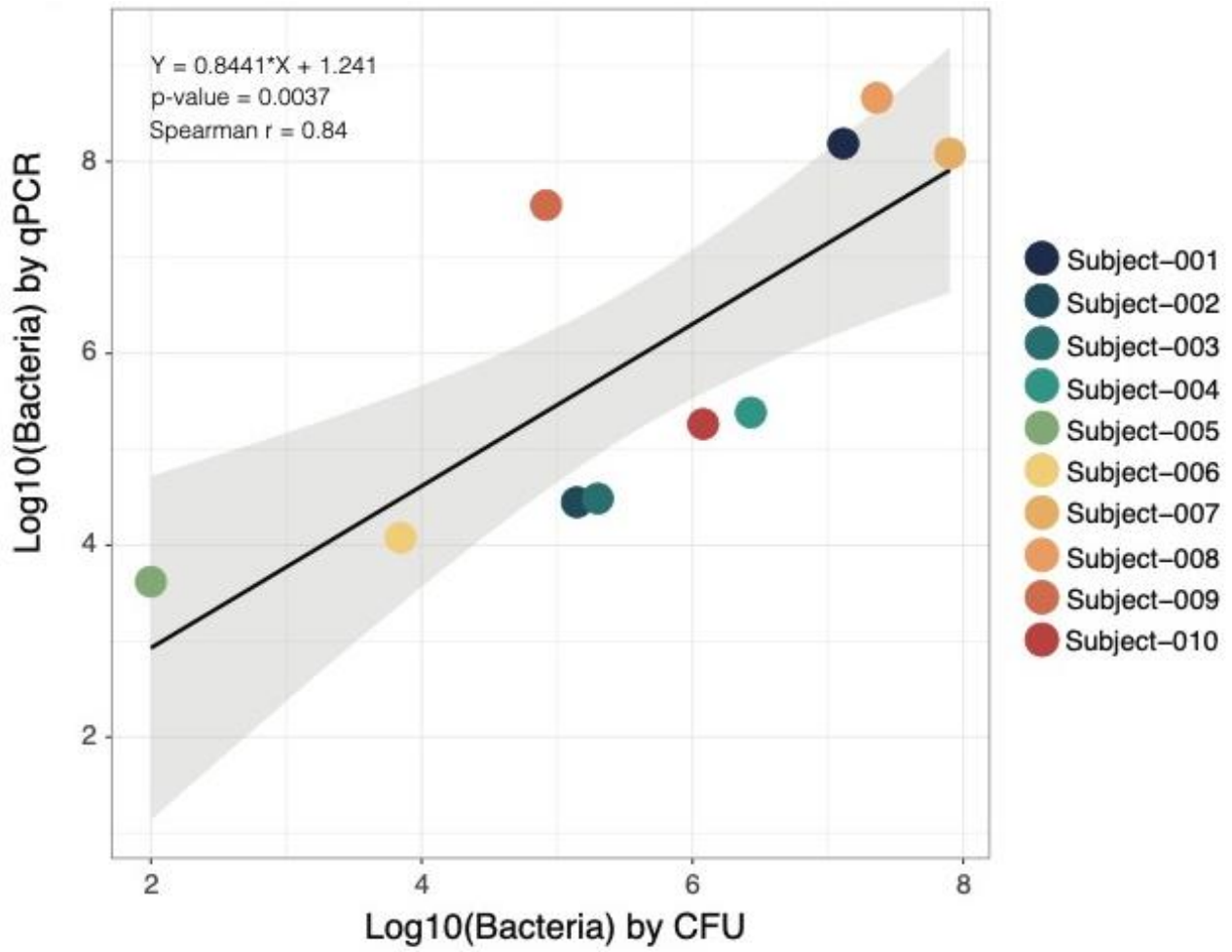


- Persistent ongoing wound
- Loosely adherent yellow slough
- High bioburden
- Polymicrobial (4+ by culture)
- No obvious biofilm by SEM
- Inflammatory Proteins detected



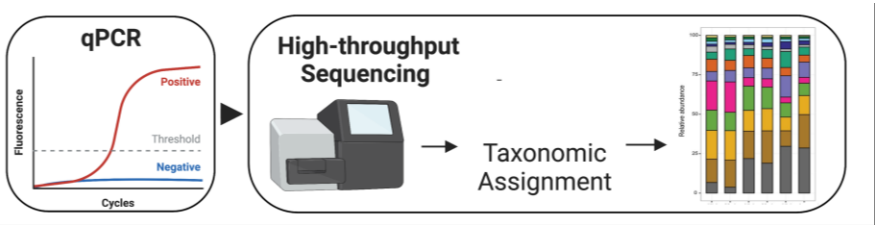
*** also detected by culture**

Slough Has a High Bioburden



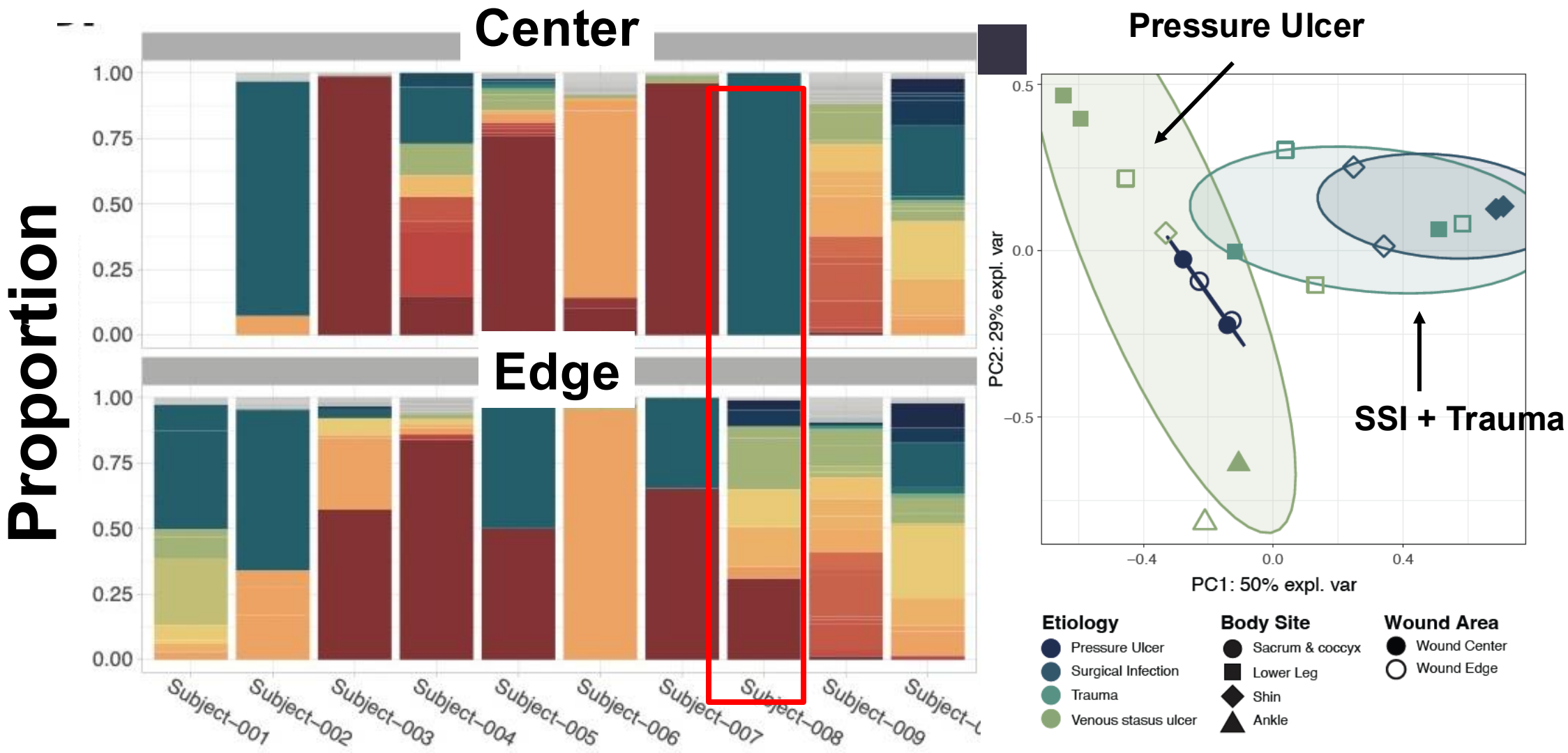
Bacterial Bioburden via **CFU** & **qPCR** strongly correlate

10 samples = 114 isolates



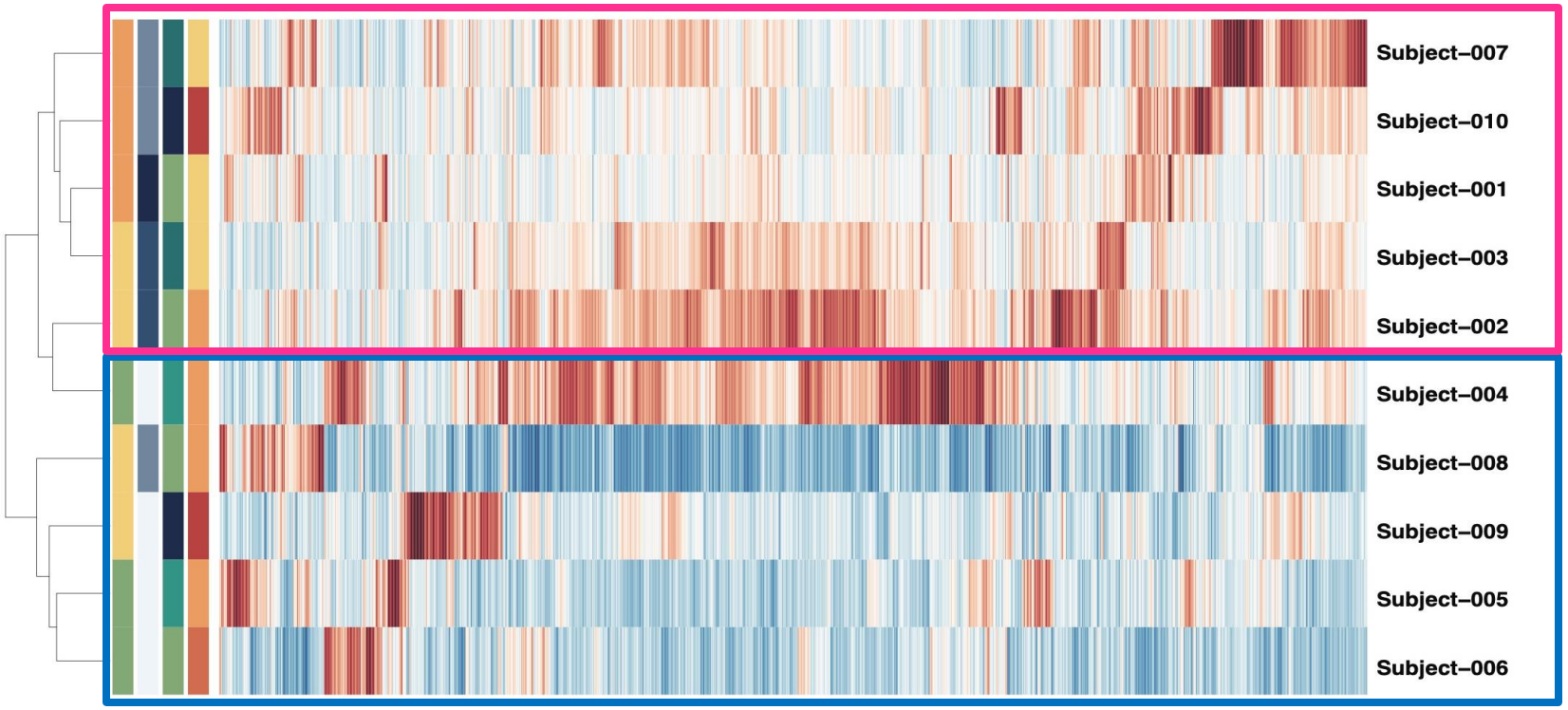
Slide by L Kalan

Slough Is Polymicrobial



Slough Protein Content Groups by Outcome

1,447 proteins identified

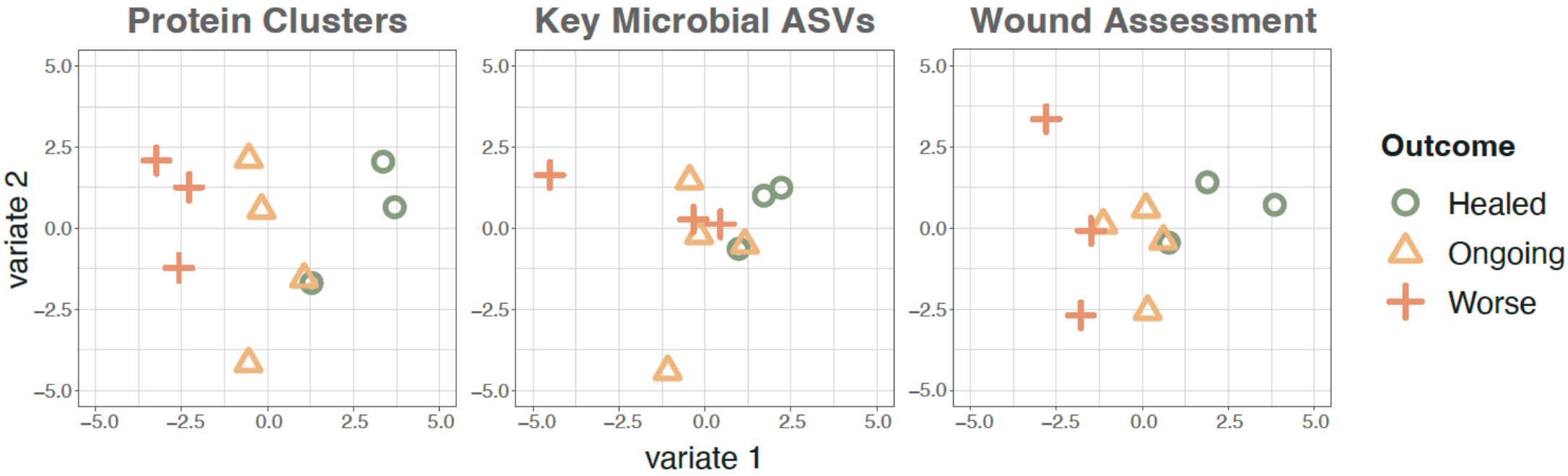


Non-healing

Persisting >2 yrs

Healing Trajectory

Protein Content Differentiates Wound Outcomes



Deteriorating Wounds

- Enriched in immune and inflammatory effectors

Healing Wounds

- Enriched in cellular metabolism and negative regulation of protease activity

Overall Summary of Findings

- 25 patient samples
- qPCR, quantitative culture, SEM, confocal microscopy, 16S sequencing, proteomics
- ~30% positive for biofilm by microscopy
- High-throughput sequencing (16S profiling) identifies 6-52 species per sample (mean = 22)
- Slough from wounds with poor trajectories are enriched in inflammatory proteins while healing wounds are enriched for normal metabolic processes.

Future Directions

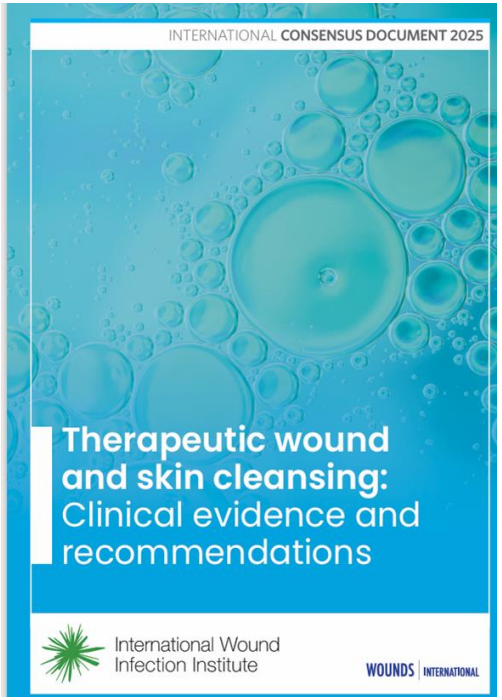
- Do color and slough consistency associate with microbial and host protein composition
- Can we build profiles to predict healing outcomes based on slough composition
- Grow the study to power for statistical considerations

Need to Differentiate Slough from Tendon

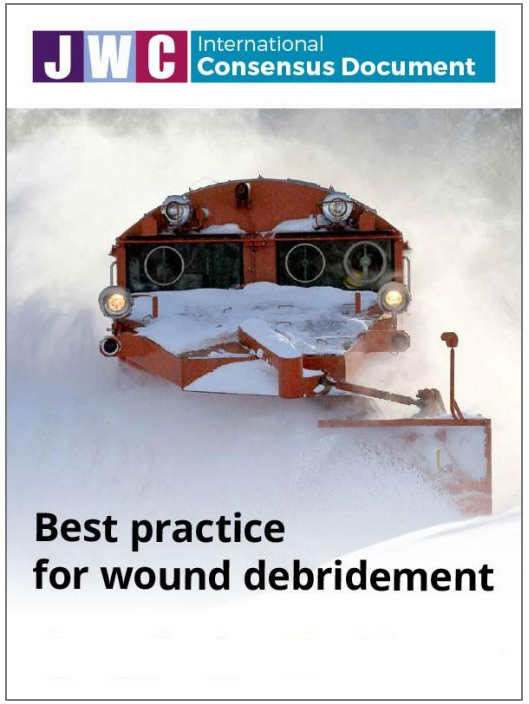
Video courtesy of Donna Larsen

Management of Slough

- Debridement
- Therapeutic wound and skin cleansing
- Moisture balance



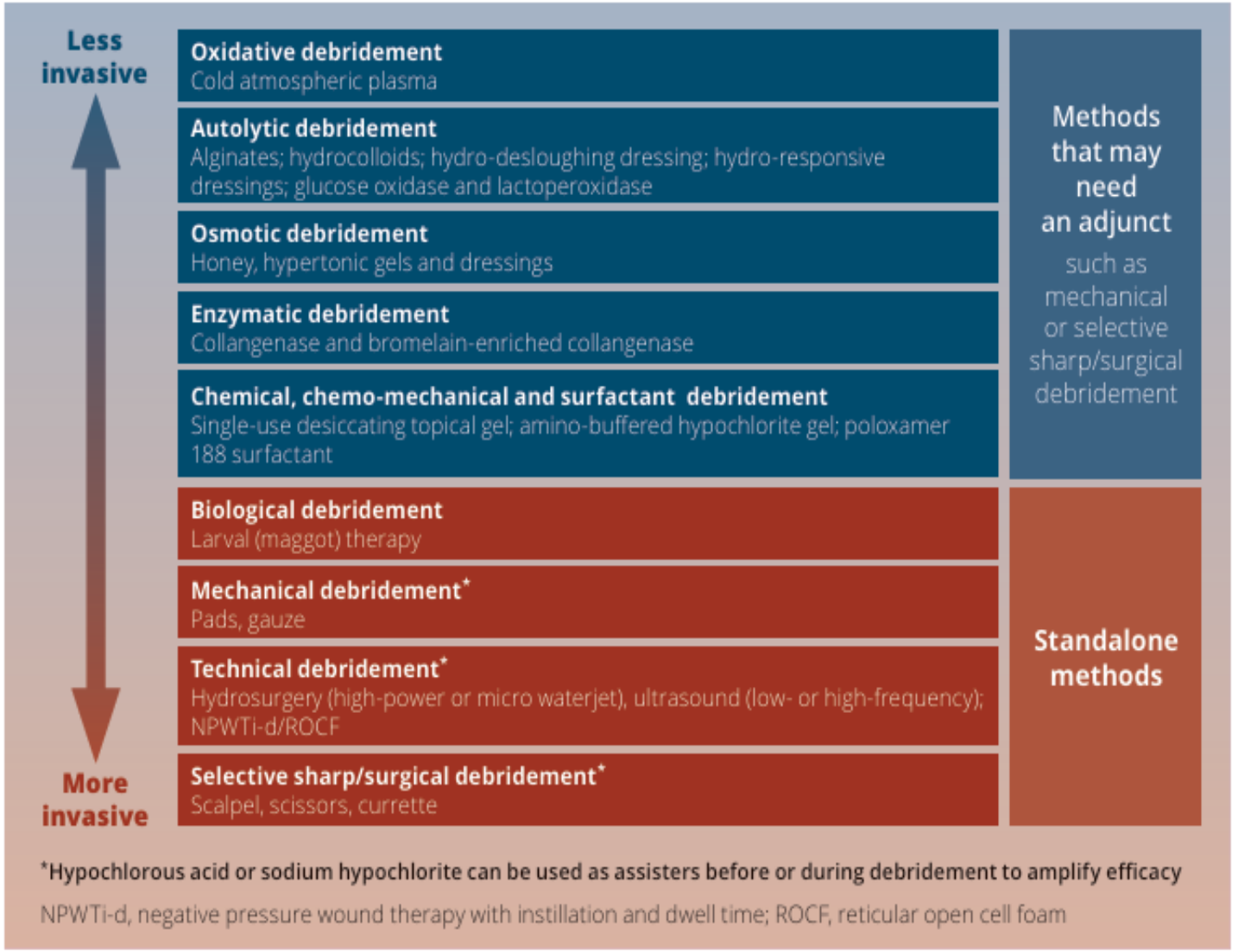
https://www.woundinfection-institute.com



https://www.journalofwoundcare.com/docs/debridementConsensus.pdf

- Surgical
- Selective Sharp
- Mechanical
- Biological
- Technical:
  - Hydrosurgical
  - Ultrasonic
  - NPWTi with ROCF
- Chemical/Enzymatic
  - Chemo-mechanical
- Surfactant
- Oxidative
  - Cold atmospheric plasma
- Osmotic
  - Honey
  - Hypertonic
- Autolytic
  - Continuous with dressings

Figure 8. Debridement methods by invasiveness and need for an adjunct



New and Emerging Technologies For Slough Dermal Removal

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Glendale, AZ

Wounds and Bacteria

- All chronic wounds are contaminated by bacteria[1]
- Wound healing can occur in the presence of bacteria[2]
- Certain bacteria (*Staphylococcus aureus*) appear to aid wound healing[3]

Thus, it is not the presence of the microorganisms, but their type and numbers that determine their influence on wound healing

1. Sibbald G, et al. Increased bacterial burden and infection: NERDS and STONES. *Wounds UK*. 2007;3(2):25-46.
2. Laato M, Niinikoski J, Lundberg C, Gerdin B. Inflammatory reaction and blood flow in experimental wounds inoculated with *Staphylococcus aureus*. *European Surgical Research.* 1998;20:33-38.
3. Levenson SM, Kan-Gruber D, Gruber C, et al. Wound healing accelerated by *Staphylococcus aureus. Archives of Surgery.* 1983;118:310-320.

Wound Bed Preparation and TIME — Tissue, Inflammation/Infection, Moisture, Edge

Tissue Debridement

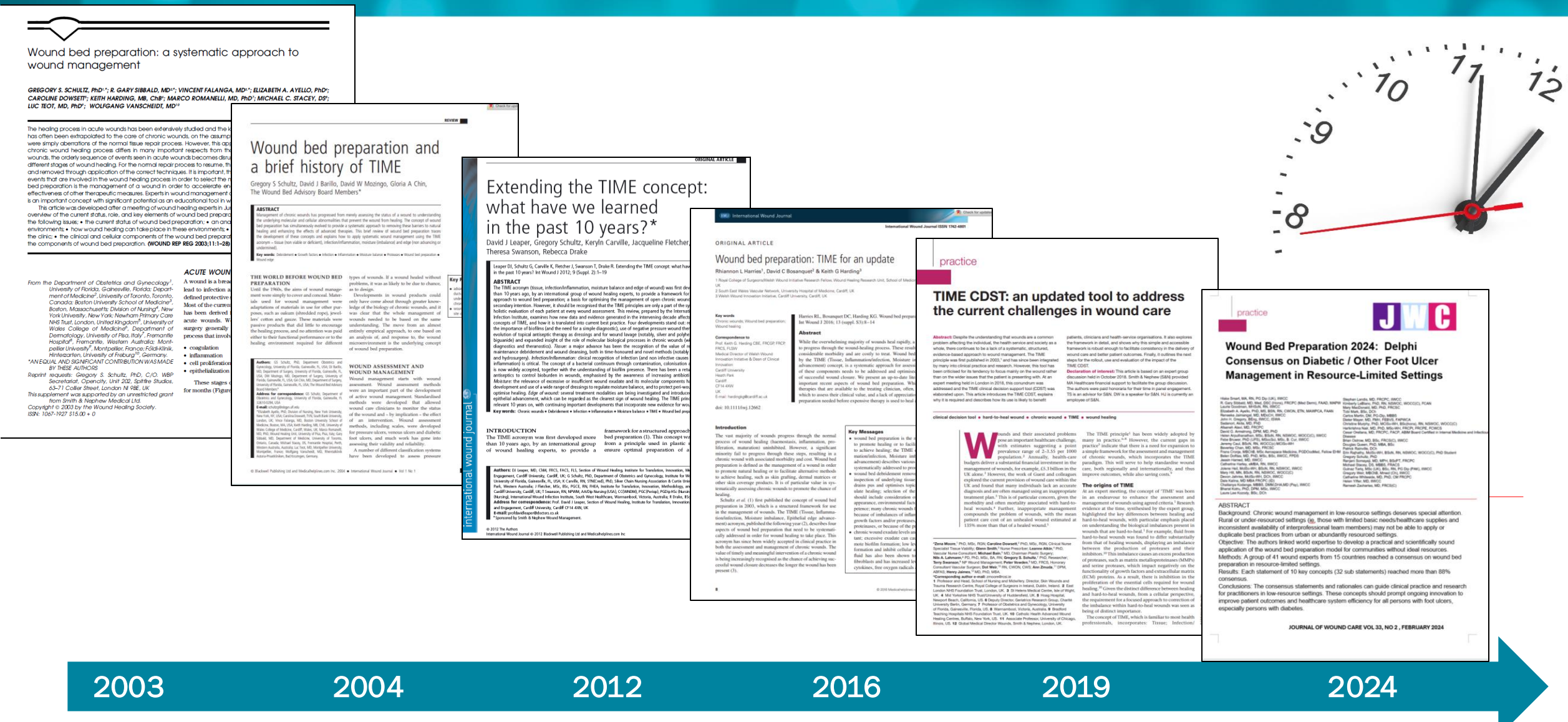
Epithelial Edge

Infection/Inflammation

Moisture Balance

Schultz GS, et al. *Wound Repair Regen*. 2003;11(Sup1):S1-S28.

21 Years of TIME



Wound bed preparation: a systematic approach to wound management

GREGORY S. SCHULTZ, PhD[1,*]; R. GARY SIBBALD, MD[2,*]; VINCENT FALANGA, MD[3,*]; ELIZABETH A. AYELLO, PhD[4]; CAROLINE DOWSETT[5]; KEITH HARDING, MB, ChB[6]; MARCO ROMANELLI, MD, PhD[7]; MICHAEL C. STACEY, DS[8]; LUC TEOT, MD, PhD[9]; WOLFGANG VANSCHEIDT, MD[10]

Wound bed preparation and a brief history of TIME

Gregory S Schultz, David J Barillo, David W Mozingo, Gloria A Chin, The Wound Bed Advisory Board Members*

Extending the TIME concept: what have we learned in the past 10 years?*

David J Leaper, Gregory Schultz, Keryln Carville, Jacqueline Fletcher, Theresa Swanson, Rebecca Drake

International Wound Journal

ORIGINAL ARTICLE

Wound bed preparation: TIME for an update

Rhiannon L Harries[1], David C Bosanquet[2] & Keith G Harding[3]

practice

TIME CDST: an updated tool to address the current challenges in wound care

practice

JWC

Wound Bed Preparation 2024: Delphi Consensus on Diabetic / Other Foot Ulcer Management in Resource-Limited Settings

2003 2004 2012 2016 2019 2024

"T" – Tissue Debridement
Remove Non-Viable or Deficient Tissue

- Goals are to remove necrotic tissue, micro-debris, slough, and reduce microbial bioburden
- Types of debridement
  - Autolytic
  - Surgical/sharp
  - Mechanical
  - Enzymatic
  - Biological
  - Hydrosurgery
  - Ultrasonic
  - Chemical
  - Honey


Autolytic


Surgical

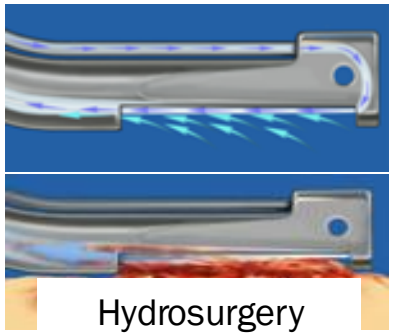

Ultrasonic


Mechanical


Enzymatic


Chemical/Oxidative


Biological


Hydrosurgery


Honey

WHS Guideline. 2007.

International Consensus Document On Wound Debridement, 2024

DEFINITION

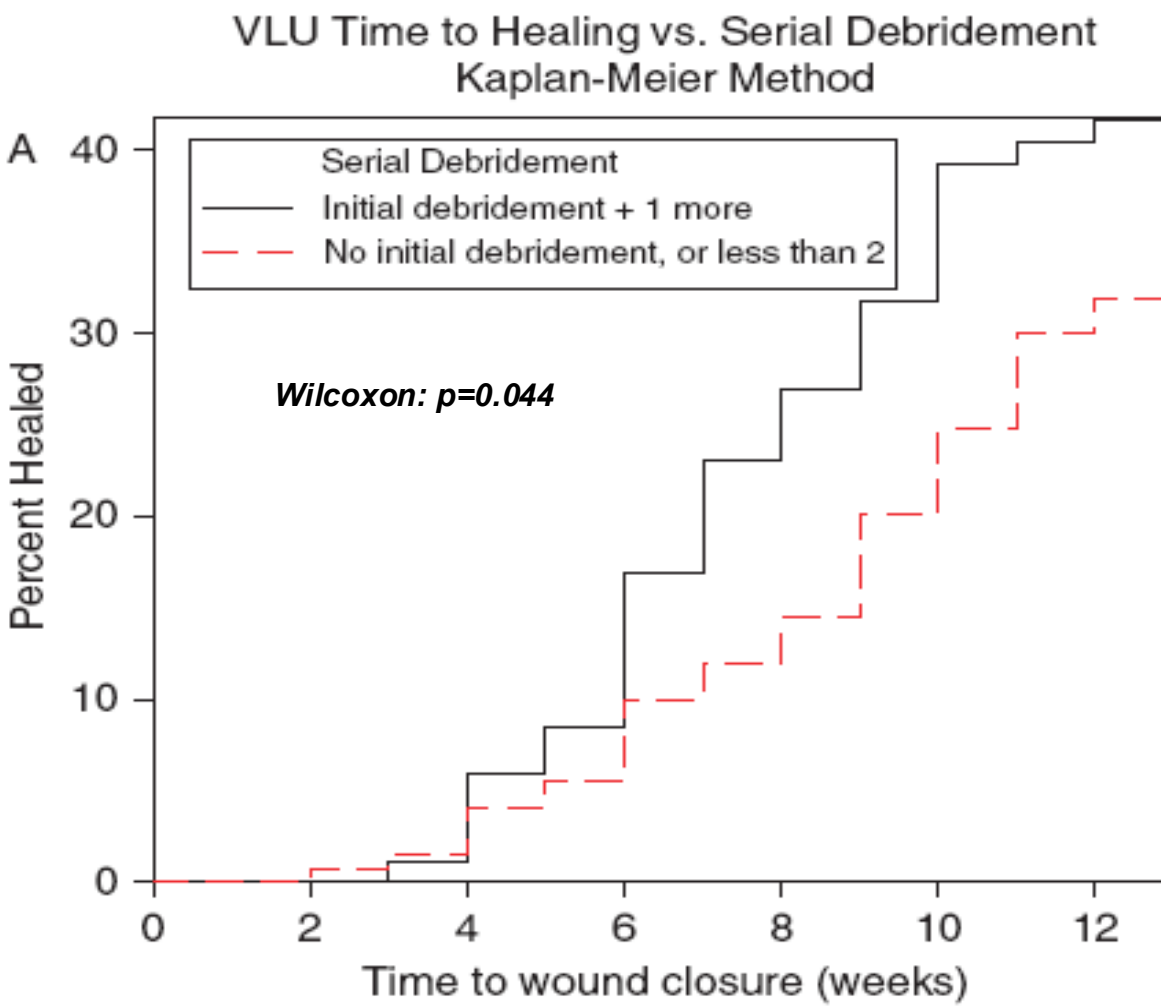
Debridement is the removal of viable and non-viable wound components, including necrotic material, slough, antimicrobial tolerant polymicrobial communities, and foreign materials. The primary goal of debridement is to reduce both microbial and non-microbial biomaterials using the most effective methods with the fewest side effects. These methods should be safely executable at the site of care.

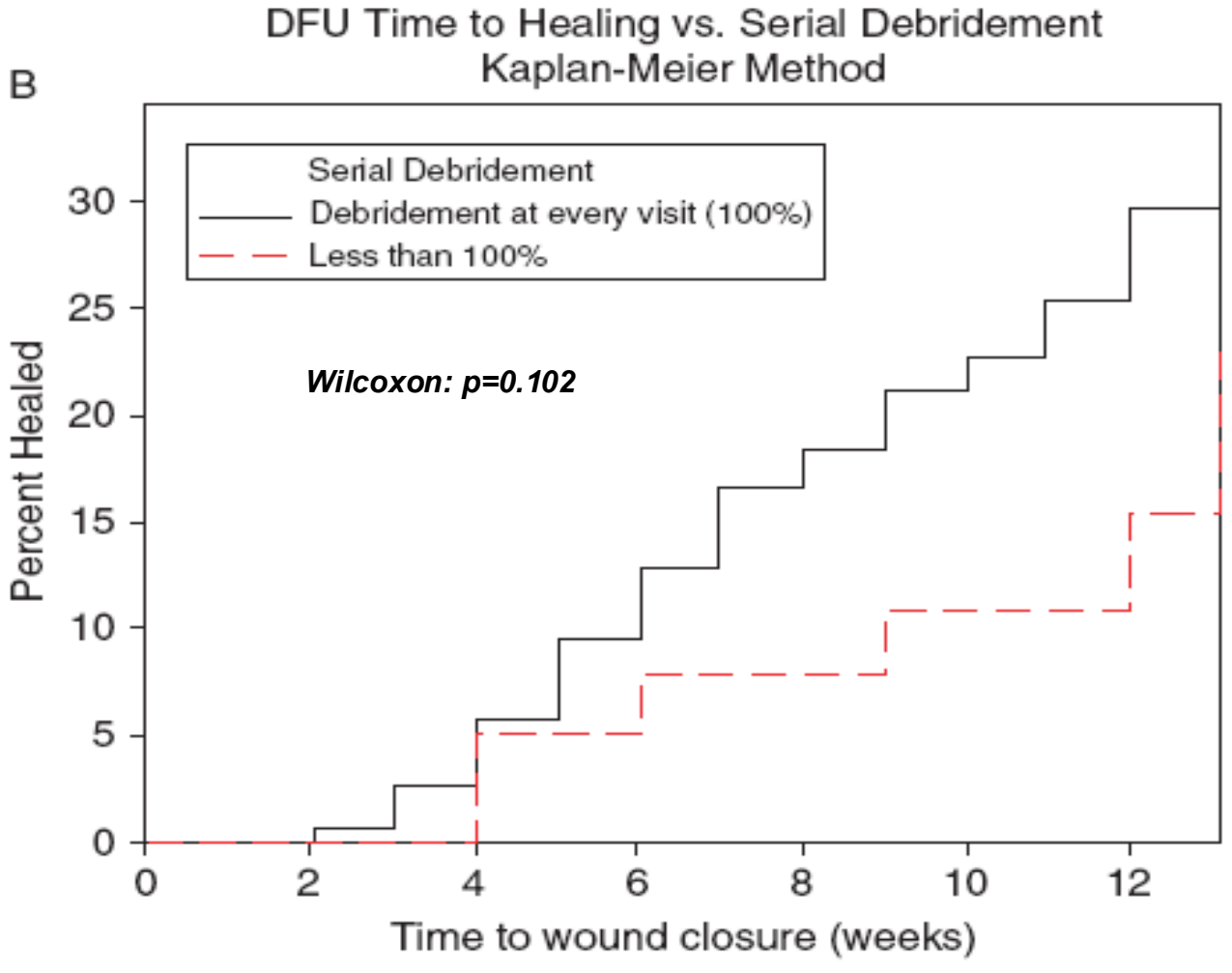
ACTION POINT

Debridement is a critical component of best practice in wound management due to its significant impact on the healing process. The rationale for debridement lies in the removal of devitalized tissue, microbial and non-microbial biomaterial, and bacterial colonies and debris from wounds. Devitalized tissue, such as necrotic or sloughy tissue, creates a barrier to wound healing. It hinders the migration of healthy cells and the formation of new blood vessels, impeding the wound's ability to progress through the healing phases. By removing this non-viable tissue, debridement promotes the growth of healthy granulation tissue and facilitates wound closure.

Mayer D, Ciprandi G, Downie F, Hampton J, Hodgson H, Lazaro-Martinez JL, Probst A, Schultz G, Stuermer EK, Tettelbach WH. International Consensus Document on Wound Debridement. *J Wound Care*. In press.

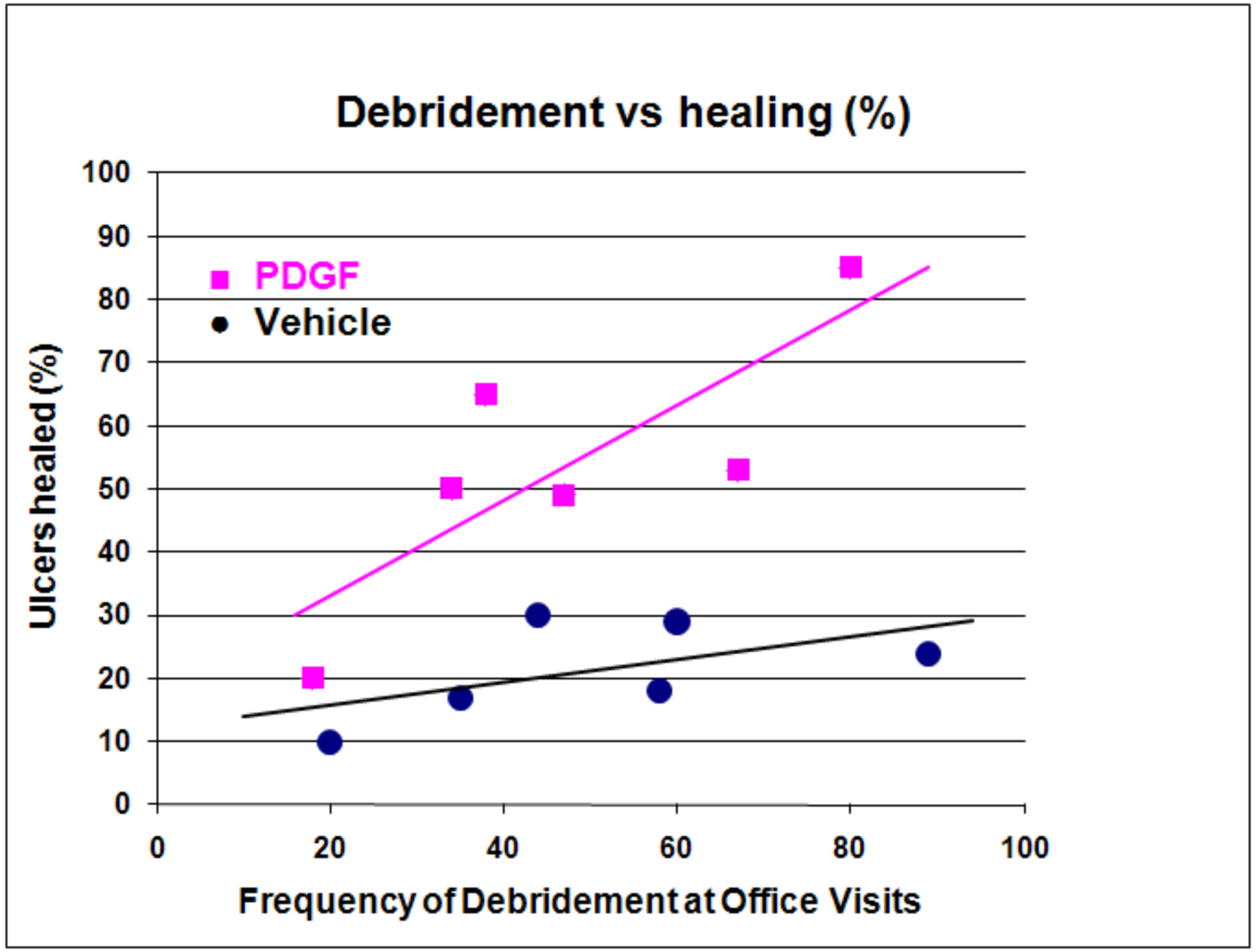
Frequent Sharp Debridement Improves Healing Of Chronic VLUs and DFUs





Cardinal M, et al. *Wound Repair Regen*. 2009;17(3):306-311.

Frequent Sharp Debridement Improves Healing of Chronic DFU and Effect of Advanced Treatments – rhPDGF



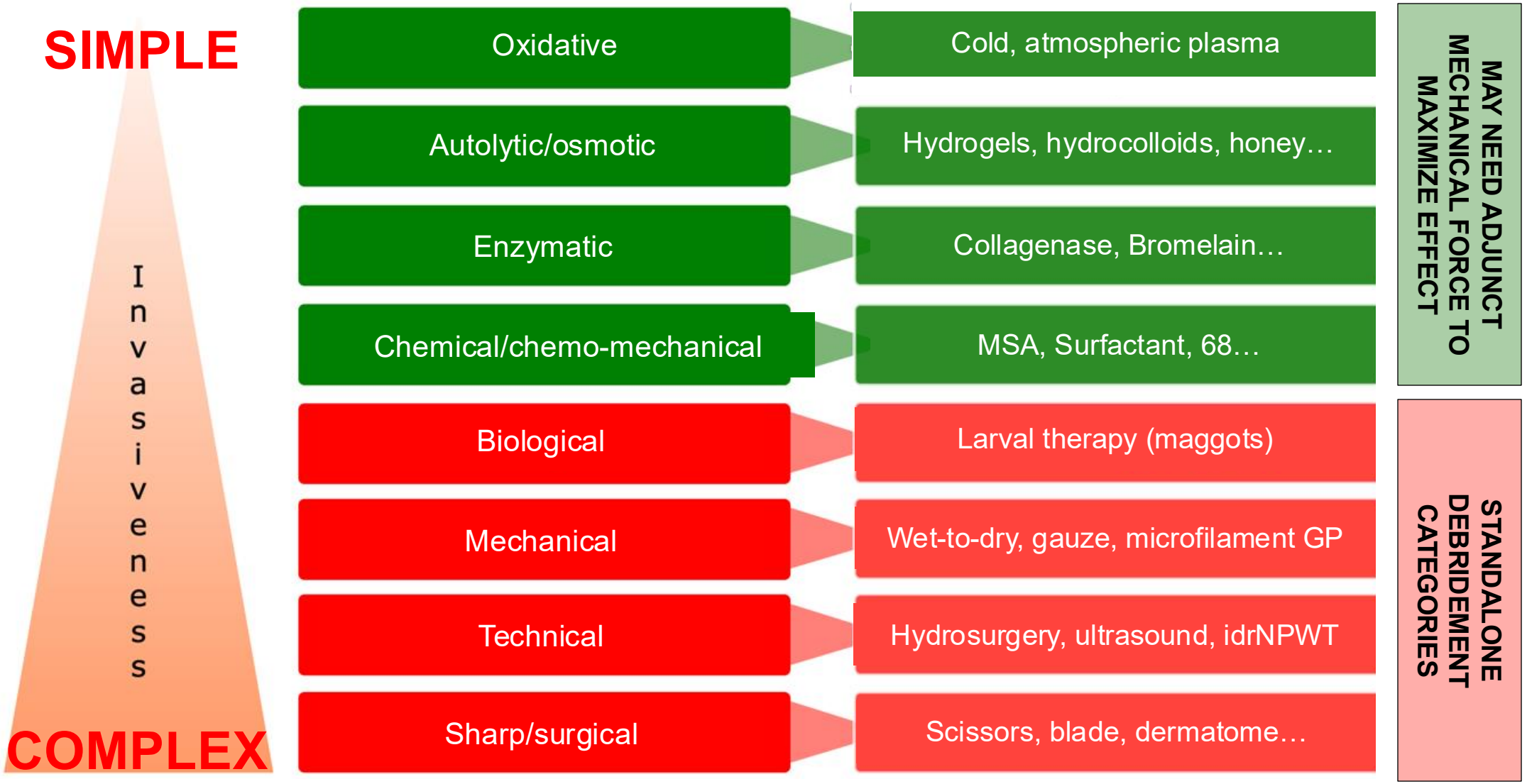
Steed DL, et al. *J.Am Coll Surg*. 1996;183(1):61-64.

Debridement: An Essential Component of Wound Bed Preparation

Sharp vs other...

Types of Debridement

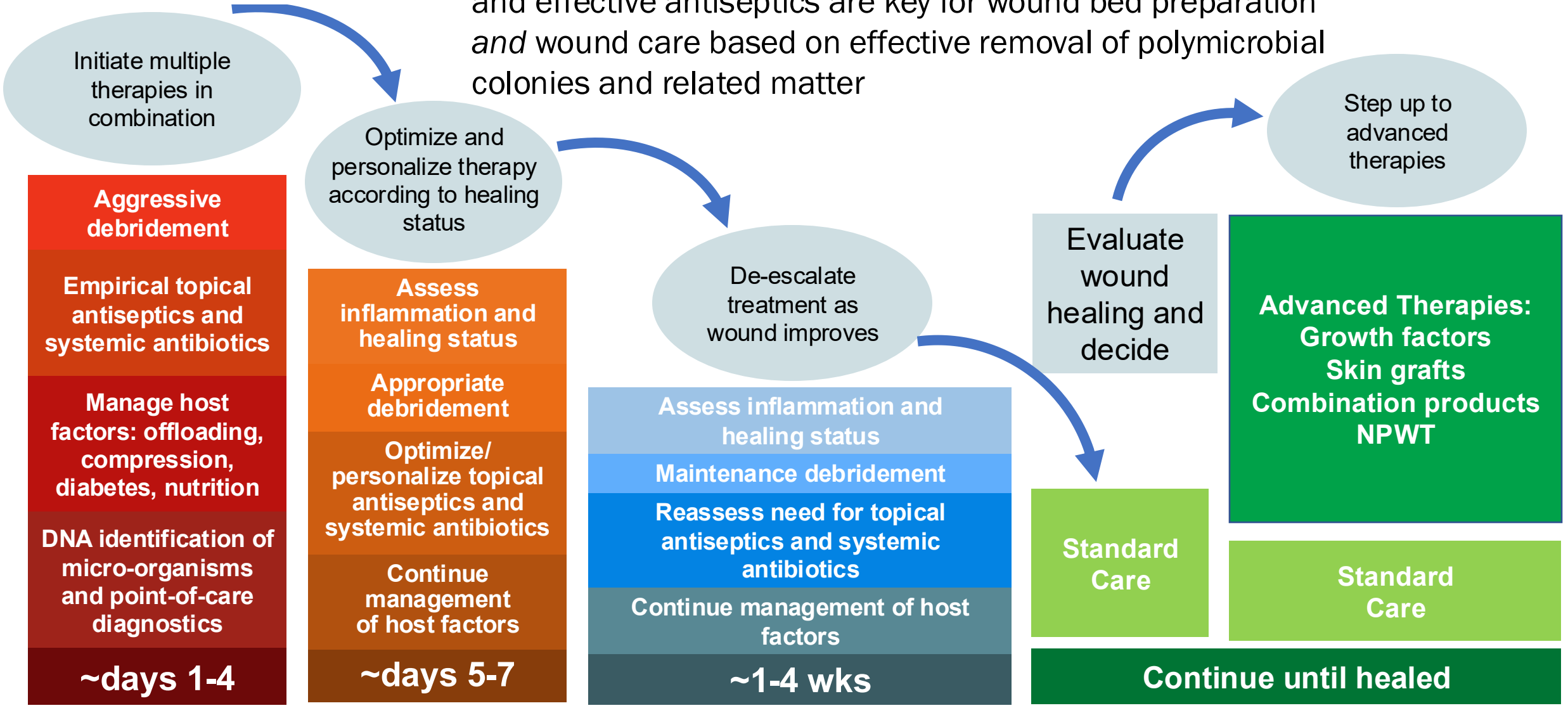
Complexity of Wound Debridement Procedures



Mayer D, et al. *J Wound Care*. In press.

Step-Down then Step-Up Treatment Strategy

Early intervention with debridement and multiple therapies and effective antiseptics are key for wound bed preparation *and* wound care based on effective removal of polymicrobial colonies and related matter



Schultz G, et al. *Wound Repair Regen*. 2017;25(5):744-757.

Microbial Colonies and Associated Debris Begin to Re-form 24 Hrs After Debridement

- "Slough or necrotic tissue can promote bacterial growth…[and] prevent the formation of granulation tissue, and subsequent re-epithelialisation, and interfere with wound contraction" (IWII)
- "More frequent debridement was associated with improved healing. Wounds that were debrided weekly or more frequently were over four times more likely to heal than wounds receiving debridement less often than weekly" (EPUAP, NPIAP, PPPIA)
- "Autolytic debridement… is insufficient to meet the debridement requirements of wound hygiene, as it takes a long time to occur, requires numerous dressing changes and can increase the risk of infection in hard-to-heal wounds" (*JWC* International Consensus Document)

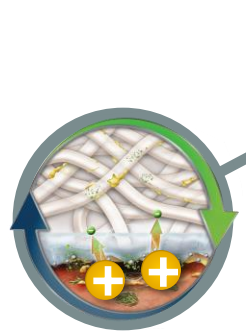
Schultz G, et al. *Wound Repair Regen*. 2017;25:744-757.

Continuous Debridement of Slough Is Needed

1. **Must be effective**
   Continuously remove slough and wound debris and mitigate re-formation of microbial colonies post-sharp debridement
2. **Must be accessible**
   All caregivers can incorporate sharp debridement throughout the continuum of care
3. **Must be easy and comfortable**
   Easy to use by healthcare providers and well tolerated by patients

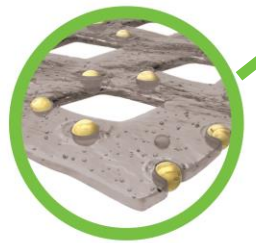
Charged fibers support the continuous debridement of slough

- Fibrin, microorganisms, and wound residue attach to negatively charged fibers to continuously clean the wound bed
- Fibers form a gel to promote moist wound healing



Antimicrobial

- Fast, broad-spectrum, antimicrobial-barrier efficacy
- Antimicrobial layers impregnated with silver (TLC-Ag healing matrix) promotes healing and atraumatic, pain-free removal



Lazareth I, et al. *Wounds.* 2008;20(6):158-166. Dissemond J, et al. *J Wound Care.* 2020;29(3):162-173. Desroche N, et al. Characterization of the antimicrobial spectrum and anti-biofilm activity of a new silver-containing dressing with poly-absorbent fibres and antimicrobial silver matrix. Poster EWMA, May 2016. Percival SL, et al. *J Wound Care.* 2015;24(11):498, 500-503, 506-510.

Case: Pressure Ulcer (Day 1)

Excisional debridement performed. Collagenase applied.

Case: Non-Healing Wound Abdominal Wall (Days 1, 47)

Collagenase applied daily for 6 wks

The Need for Debridement Options

Current State

- Feeling stuck in a pigeonhole of 5 ways to prepare a wound bed

Clinician Wants

- To safely clean a wound and “do no harm” to healthy tissue
- Something with wide variety of use cases and safe with other modalities

Market

Evolutionary

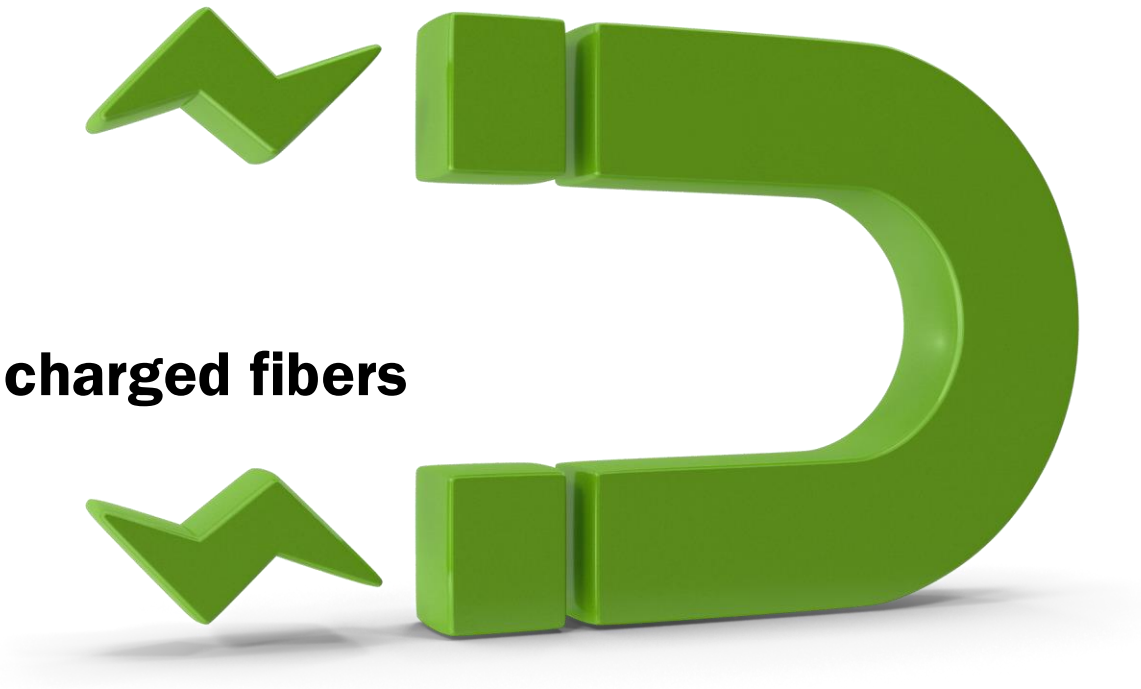
vs

Revolutionary

How Do Charged Fibers Work?

Biomaterials behave in predictable ways within complex tissue environments

- Steric exclusion
- Hydrophobic interactions
- Hydrogen bonds
- **Fibers have a high attraction to positively charged fibers**
- Electrostatic interactions



1. Meaume, S., Dissemond, J., Addala, A. Evaluation of two fibrous wound dressings for the management of leg ulcers: results of a European randomised controlled trial (EARTH RCT). J Wound Care 2014; 23: 3, 105-116.

Case Summary: LE Complex Wounds

- 70y Male with complex wounds RLE uncertain etiology. Vascular work-up negative for arterial or venous disease. Patient is poor surgical candidate, requires continuous debridement to allow for wound progression.
- Medical history: No known CAD, DM, HTN
- Treatment
  - Excisional debridement in office.
  - Negatively charged dense fibers initiated to expedited debridement
  - Treatment is ongoing

RLE Complex Wound (Day 1)

RLE Complex wound with eschar, slough and heavy exudate

RLE Complex Wounds (4 Wks)

RLE Complex wound with less slough and thinner eschar

BLE Complex Wounds (Day 1)

RLE Complex wound with eschar, slough, and heavy exudate

BLE Complex Wounds (4 Wks)

RLE Complex wound with less slough and thinner eschar

Case Summary: Venous Stasis Ulcers

- 59y Male with longstanding venous stasis ulcers declined surgical intervention; requires continuous debridement to allow for wound progression.
- Medical history: Obesity, HTN
- Treatment
  - Excisional debridement in office.
  - Negatively charged dense fibers initiated to expedited debridement
  - Treatment is ongoing

Venous Stasis Ulcers (Day 1)

LLE Venous ulcer with slough and heavy exudate

Venous Stasis Ulcers (3 Months)

LLE Venous ulcer reduced in size, slough, and exudate

Combining Technologies

Highly Charged Fiber (HCF)* dressings to support debridement in conjunction with debridement via clostridial collagenase

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INTRODUCTION

Complex wounds need highly effective debridement to heal optimally, or to be prepared optimally for primary closure via surgery. Debridement can be done via excision, but this acute procedure can be subsequently augmented with the use of enzymatic products such as clostridial collagenase. Additional debridement support may be obtained, via the use of newly available highly charged fiber dressings that can be used synergistically with other modalities such as excisional debridement, or enzymatic debridement. In particular we studied wounds treated with collagenase with conjunctive use of HCF dressings, and we report our results.

METHOD

Five cases of complex wounds are presented, two of these were destined for surgical closure pending appropriate wound bed preparation. Three wounds were planned and destined for secondary closure. Cases 1-5 details and images shows how the wounds progressed via the judicious use of sharp debridement, enzymatic debridement, and debridement support from Highly Charged Fiber (HCF) dressings.

RESULTS

We found that the use of the HCF dressing allows the continuation of slough removal, post excisional debridement and collagenase debridement enzyme, allowing successful surgical closure in two wounds, and stepdown to secondary closure in three others following optimal cleansing/ debridement of the wounds.

CASE 1 – RIGHT ISCHIAL PRESSURE ULCER

61 yo male with paraplegia with h/o multiple pressure ulcers including progressive right ischial ulcer with necrotic debris, despite wound management and offloading.
Medical history: Paraplegia
Treatment:

- Clostridial Collagenase utilized following office excisional debridements.
- Negatively Charged Densed fibers added to Clostridial Collagenase to expedited debridement
- Taken to OR for flap closure once wound bed preparation deemed adequate
- Placental allograft placed to optimize healing.
- Incisional V.A.C.® Therapy initiated with a 3M™ Prevena™ Customizable Dressing immediately following closure

CASE 2 – NON HEALING SURGICAL WOUND LOWER BACK

74 yo female s/p spine surgery complicated by PE requiring antigoagulation that resulted in hematoma and secondary dehiscence. | Medical history: DVT, PE (On anticoagualants) | Treatment:

- Clostridial Collagenase utilized following office excisional debridements.
- Negatively Charged Densed fibers added to Clostridial Collagenase to expedited debridement
- Taken to OR for flap closure once wound bed preparation deemed adequate
- Placental allograft placed to optimize healing.
- Incisional V.A.C.® Therapy initiated with a 3M™ Prevena™ Customizable Dressing immediately following closure

CASE 2 – CONT'D

CASE 3 – THIGH WITH FULL THICKNESS NECROSIS

70yo female s/p recurrent ventral hernia repair with postoperative dehiscence and tissue necrosis.
Medical history: Obesity, Pace maker
Treatment:

- Clostridial Collagenase utilized following office excisional debridements.
- Negatively Charged Densed fibers added to Clostridial Collagenase to expedited debridement
- Secondary healing without need for surgical intervention

CASE 4 – THIGH WITH FULL THICKNESS NECROSIS

49 yo male with paraplegia with failed flap with extensive full thickness necrosis thigh.
Medical history: Paraplegia | Treatment:

- Excisional debridement in office.
- Clostridial Collagenase utilized following office excisional debridements.
- Negatively Charged Dense fibers added to Clostridial Collagenase to expedited debridement
- NPWT initiated

CASE 5 – THIGH WITH FULL THICKNESS NECROSIS

57 yo male with paraplegia with right ischial pressure ulcer extending to bone (Stage 4). Presents with extensive debris with deep tissue necrosis | Medical history: Paraplegia | Treatment:

- Clostridial Collagenase utilized following office excisional debridements.
- Negatively Charged Dense fibers added to Clostridial Collagenase to expedited debridement
- Taken to OR for flap closure once wound bed preparation deemed adequate
- Placental allograft placed to optimize healing.
- Incisional V.A.C.® Therapy initiated with a 3M™ Prevena™ Customizable Dressing immediately following closure

CONCLUSION

The results show that though more research is indicated in this area, the combination of established debridement methods, such as excisional debridement and enzymatic debridement, can likely be supported by the continuous slough removal properties of the Highly Charged Fiber (HCF) dressings.

REFERENCES

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2. with a dressing combining poly-absorbent fibres and a silver matrix. J Wound Care. 2016 Oct;25(10):577-84.
3. Percival SL. Restoring balance: biofilms and wound dressings. J Wound Care. 2018 Feb;27(2): 102-13
4. Desroche N, et al. Evaluation of in vitro anti-biofilm activities of two dressings with poly-absorbent dressing fibres and a DACC coated dressing. Poster EWMA 2017
5. Meaume, S., Dissemond, J., Addala, A. Evaluation of two fibrous wound dressings for the management of leg ulcers: results of a European randomised controlled trial (EARTH RCT). J Wound Care 2014; 23: 3, 105–116.
6. N. Desroche et al, Evaluation of the anti-biofilm activity of a new poly-absorbent dressing with a silver matrix*using a complex in vitro biofilm model. Poster Wounds UK 2017.
7. Lazareth I, et al. The role of a silver releasing lipido-colloid contact layer in venous leg ulcers presenting inflammatory signs suggesting heavy bacterial colonization: Results of a randomized controlled study. Wounds. 2008;20(6):158–66
8. Dalac S., Sigal L., Addala A., et al Clinical evaluation of a dressing with poly absorbent fibres and a silver matrix for managing chronic wounds at risk of infection: a non-comparative trial. J Wound Care, Vol 25, No 9, September 2016

Case Summary: Right Ischial Pressure Ulcer

- 61y Male with paraplegia with h/o multiple pressure ulcers, including progressive right ischial ulcer with necrotic debris despite wound management and offloading
- Medical history: Paraplegia
- Treatment
  - Clostridial collagenase utilized following office excisional debridements
  - Negatively charged dense fibers added to clostridial collagenase to expedite debridement
  - Taken to OR for flap closure once wound bed preparation deemed adequate
  - Placental allograft placed to optimize healing.
  - Incisional NPWT initiated with a customizable incision management dressing immediately following closure

Necrotic Pressure Ulcer (Day 1)

Debridement supported with negative charged fibers applied daily

Necrotic Pressure Ulcer (Day 1, 7)

Necrotic Pressure Ulcer (Day 7)

Necrotic Pressure Ulcer (Day 7)

Necrotic Pressure Ulcer (Day 7)

Debridement supported with negative charged fibers applied daily until definitive surgical closure performed

Necrotic Pressure Ulcer (6 Wks)

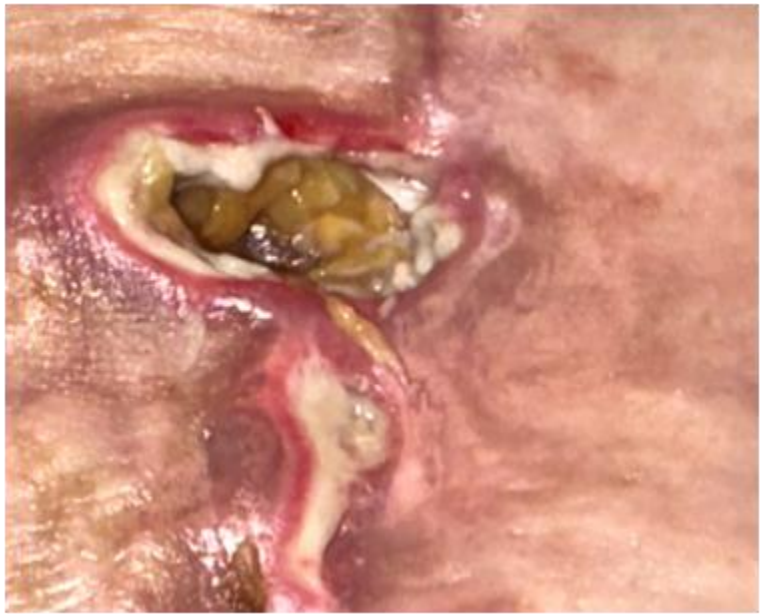
Case Summary: Non-Healing Surgical Wound Abdomen

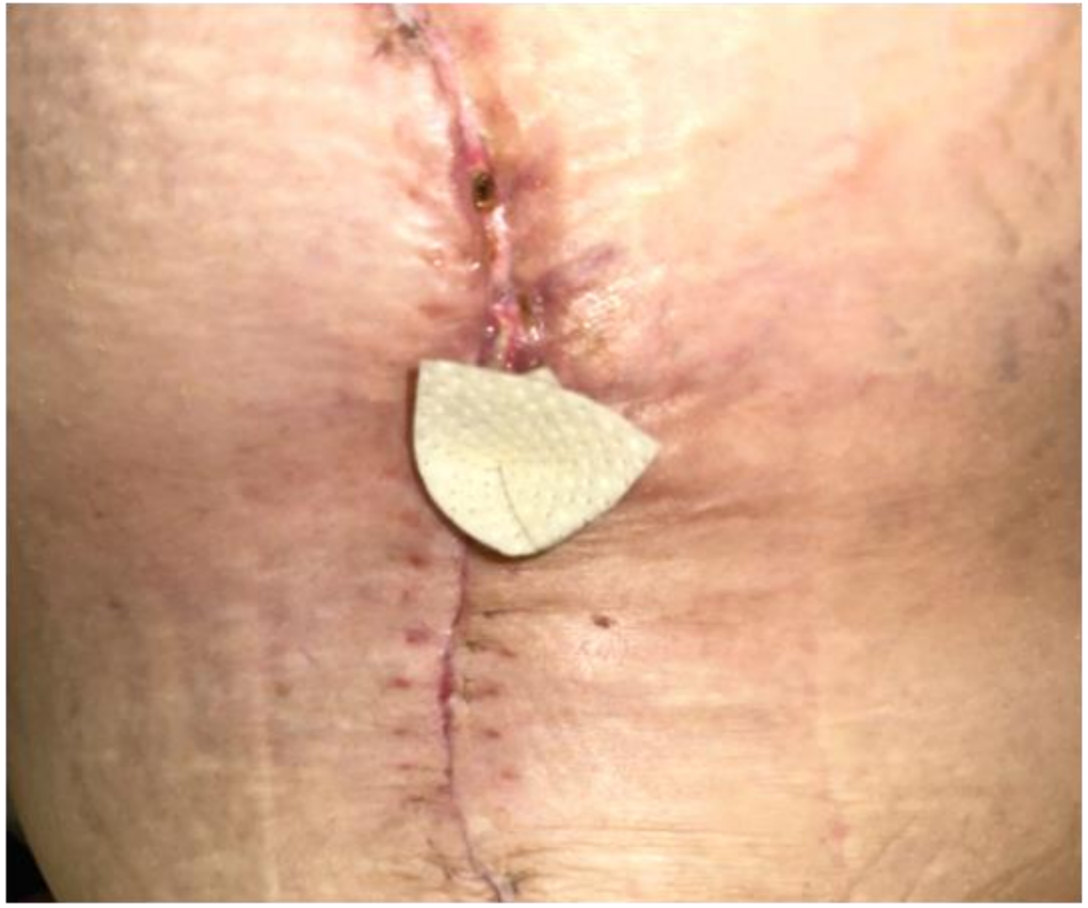
- 70y Female s/p recurrent ventral hernia repair with post-operative dehiscence and tissue necrosis
- Medical history: Obesity, pacemaker
- Treatment
  - Clostridial collagenase utilized following office excisional debridements
  - Negatively charged dense fibers added to clostridial collagenase to expedite debridement
  - Secondary healing without need for surgical intervention

Non-Healing Wound Abdomen (Day 1)

Non-Healing Wound Abdomen (Day 7)

Non-Healing Wound Abdomen (Day 7)

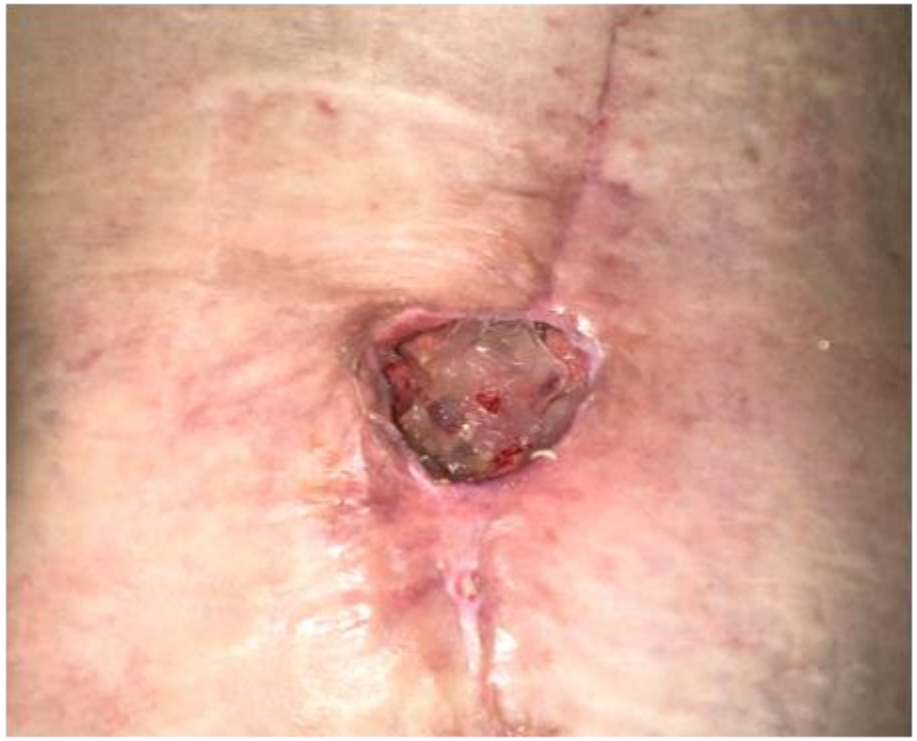




Non-Healing Wound Abdomen (Day 21)

Non-Healing Wound Abdomen (Day 21)

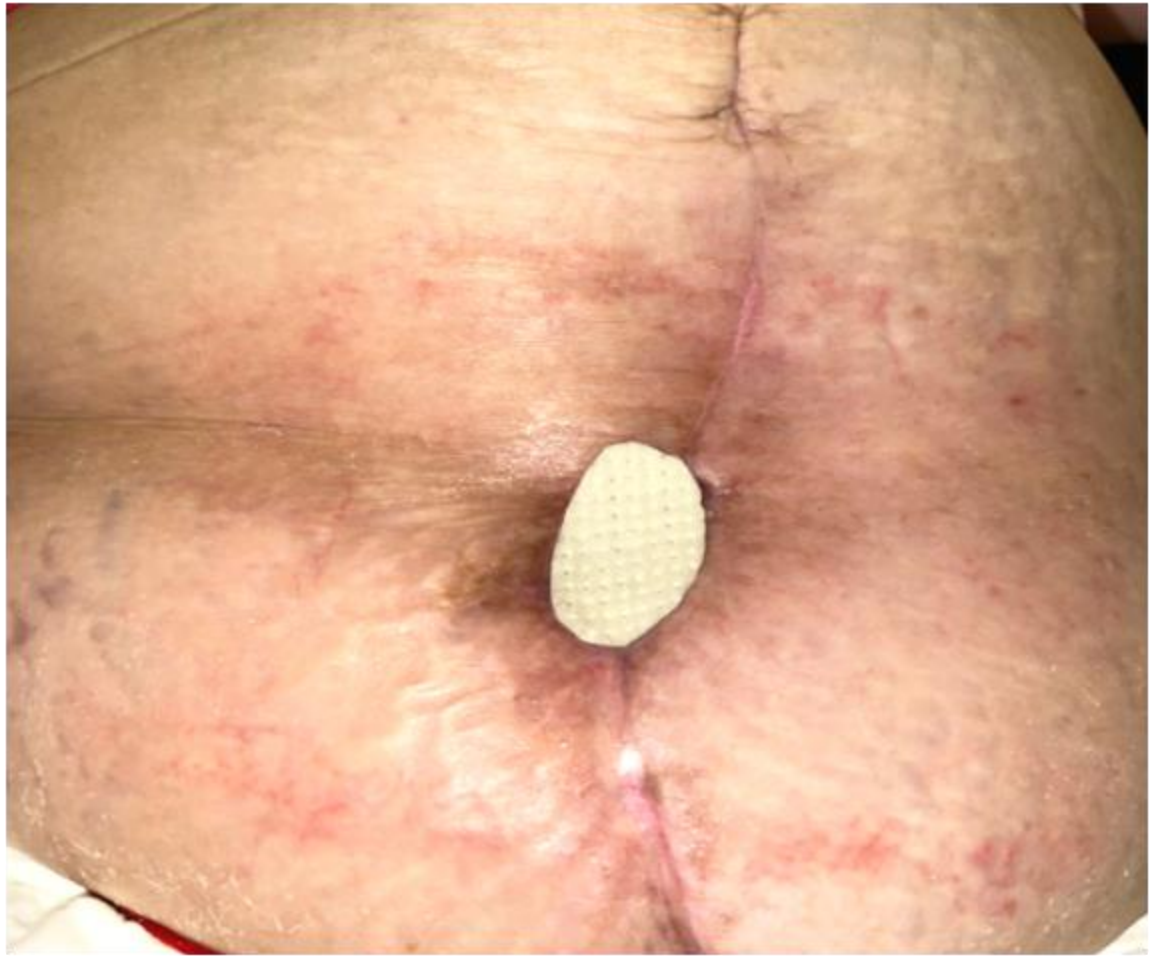
Non-Healing Wound Abdomen (Day 21)



Non-Healing Wound Abdomen (6 Wks)

Non-Healing Wound Abdomen (8 Wks)

Non-Healing Wound Abdomen (8 Wks)



Non-Healing Wound Abdomen (10 Wks)

Case Summary: Thigh with Full Thickness Necrosis

- 49y Male with paraplegia with failed flap with extensive full thickness necrosis thigh
- Medical history: Paraplegia
- Treatment
  - Excisional debridement in office
  - Clostridial collagenase utilized following office excisional debridements
  - Negatively charged dense fibers added to clostridial collagenase to expedite debridement
  - NPWT initiated

Necrosis Left Thigh (Day 1)

Left thigh with full thickness necrosis

s/p Removal eschar

Necrosis Left Thigh (Day 1)

Necrosis Left Thigh (Day 1)

CC application followed by non-adherent

Negatively charged dense fibers

Necrosis Left Thigh (Day 7)

Necrosis Left Thigh (Day 7)

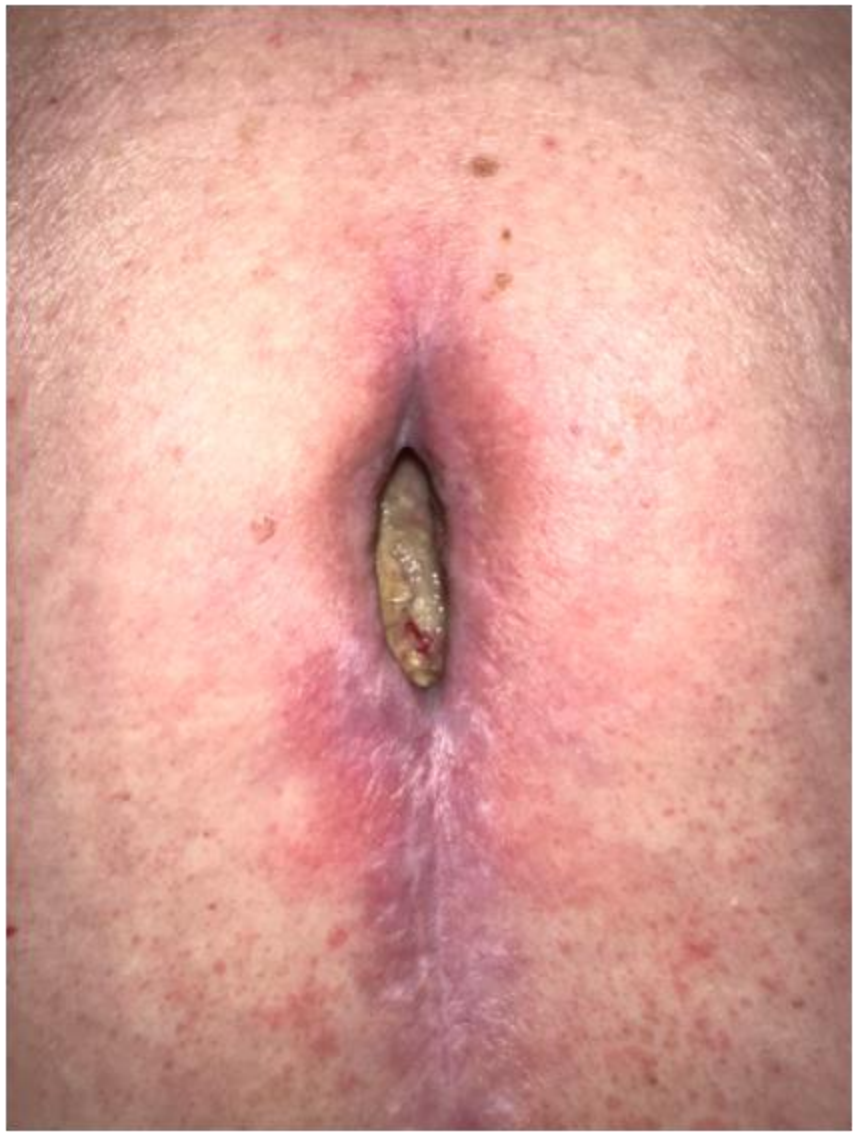
CC application followed by non adherent and

Negatively charged dense fibers

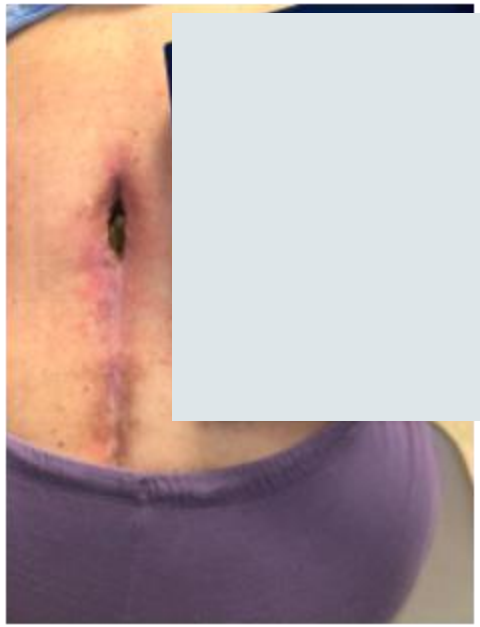
Case Summary: Non-Healing Surgical Wound Lower Back

- 74y Female s/p spine surgery complicated by PE requiring anticoagulation that resulted in hematoma and secondary dehiscence.
- Medical history: DVT, PE (on anticoagualants)
- Treatment
  - Clostridial collagenase utilized following office excisional debridements
  - Negatively charged dense fibers added to clostridial collagenase to expedited debridement
  - Taken to OR for flap closure once wound bed preparation deemed adequate
  - Placental allograft placed to optimize healing
  - Incisional NPWT initiated with customizable incision management dressing immediately following closure

Non-Healing Wound Spine (Day 1)



Non-Healing Wound Spine (Day 1)



Non-Healing Wound Spine (Day 1)

Non-Healing Wound Spine (Day 10)

Non-Healing Wound Spine (Day 10)

Case Summary: Right Ischial Pressure Ulcer

- 57y Male with paraplegia with right ischial pressure ulcer extending to bone (Stage 4) presents with extensive debris with deep tissue necrosis
- Medical history: Paraplegia
- Treatment:
  - Clostridial collagenase utilized following office excisional debridements
  - Negatively charged dense fibers added to clostridial collagenase to expedited debridement
  - Taken to OR for flap closure once wound bed preparation deemed adequate
  - Placental allograft placed to optimize healing.
  - Incisional NPWT initiated with customizable incision management dressing immediately following closure

Right Ischial Ulcer (Day 1)

Right Ischial Ulcer (Day 1)

Right Ischial Ulcer (Day 1)

Right Ischial Ulcer (6 Wks)

Right Ischial Ulcer (6 Wks)

Right Ischial Ulcer (6 Wks)

Summary

- Debridement is the cornerstone for wound bed preparation and reduction of bacterial burden to allow for wound healing
- There is a role for integral debridement with a variety of techniques to optimize patient outcome
- Negatively charged fibers may assist in the to removal of slough, bioburden, and necrotic tissue, and associated debris that may lead to infection free in highly complex wounds/patients
- Combining technologies may lead to faster wound bed preparation in anticipation of surgical closure and or expedite healing secondarily