BIOPHYSICAL AGENTS IN WOUND CARE

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Considerations For Adding Alternative/Adjunctive Modalities to Facilitate Wound Healing

- Reduction in wound area 10-15%/week represents normal healing
- This rate of healing does not mandate a change in current wound healing strategy
- Consider alternative/adjunctive modalities if this level not met "consistently" on weekly basis
Electromagnetic Spectrum
- Electrical Stimulation
- Diathermy
- Ultraviolet
- Infrared
- Light Emitting Diodes

Mechanical & Acoustic
- Whirlpool (Rare Indications)
- MHz Ultrasound
- kHz Ultrasound

Positive Pressure
- Intermittent Pneumatic Compression
- Topical Oxygen
- Hyperbaric Oxygen

Positive & Negative Pressure
- Pulsed Lavage
- Suction
- NPWT

Electrical Stimulation (ES)

- One of the most cost effective, therapeutically efficacious modalities
- Used for more than 3 decades to accelerate the rate of chronic wound healing
- Strength of evidence rating for this modality was increased from Level B to Level A in 1999
- Reimbursement from CMS when documentation reflects wounds meets “chronic” definition

Pressure Ulcer Prevention and Treatment Following Spinal Cord Injury

- Published by the Paralyzed Veterans of America
- States electrical stimulation qualifies as a stand-alone intervention and no longer classifies it as an adjunctive therapy

(Clinical Practice Guideline: Pressure Ulcer Prevention and Treatment Following Spinal Cord Injury. Paralyzed Veterans of America, Washington, DC)
Consider the use of direct contact electrical stimulation (ES) in the management of recalcitrant Stage II as well as Stage III and IV pressure ulcers to facilitate wound healing.

Strength of Evidence (A)
Electrical Stimulation in Wound Healing

• Electrical current transfers energy to wound via electrodes to the skin

• Evidence supports delivery of an electrical current into chronic wound tissue enhances wound healing

Theory: How ES works
  • Related to “current of injury”

• ES mimics this “current of injury” to accelerate/“jump start” wound healing cascade
Cellular Processes & Physiological Responses

• ↑ blood perfusion (FDA main label indication for treating wounds)
  – Cutaneous (microcirculatory)
  – Periwound
  – Arterial

• Stimulation of fibroblasts to enhance collagen and DNA synthesis

• ↑ number of receptor sites for growth factor interface

• ↑ migration and proliferation of cells at wound site
  – Neutrophils
  – Macrophage
  – Fibroblasts
Cellular Processes & Physiological Responses-Con’t.

- ↑ collagen deposition
- ↓ edema
- ↓ wound pain
- ↓ peripheral neuropathy pain
- • Bactericidal effects
E-Stim Currents

- Electrical current may be delivered as:
  - Low-intensity direct current (LIDC)
  - High-voltage pulsed current (HVPC)
  - Transcutaneous electrical nerve stimulation (TENS)
- High voltage pulsed current (HVPG) - current used most often for wound treatments in the last decade
Applications for Tissue Repair

- Exogenous (externally applied) electric currents that are delivered to the wound tissues via at least 2 electrodes which are placed:
  - Directly into the wound
  - Around the wound (periwound tissue)
  - By using a stocking or glove electrode garment to the affected limb.
Bioelectric Antimicrobial Wound Dressing

- Sustained electrical micro current
- Stimulates physiologic current of injury
- Induce, enhance, accelerate wound healing

Application Under NPWT
Indications

- Pressure ulcers
- Venous insufficiency ulcers
- Arterial ulcers
- Diabetic neuropathic ulcers
- Burns
- Dehisced surgical wounds
67 y/o with pressure ulcer, DM & PAD
Amputation L toes
\[\text{ABI}=0.51\]

Treatment
- Debridement
- ES delivered stocking electrodes
- PDGF
- Infrared light
NOTE

• Electrical stimulation can be a first line or adjunct treatment and **should** be used in combination with other moist wound therapy interventions.
E-Stim References


6. Kloth, LC: 5 questions and answers about electrical stimulation. Advances in Skin & Wound Care, May/June, 2001


What is Diathermy?

- Use of electromagnetic energy to produce heat within tissues
- Heats tissue 3-5 cm below surface of skin without overheating skin or subcutaneous tissues
- Treatment applied with specialized machine using coils that direct electromagnetic energy into tissue
Indications for Use of Diathermy

- Decreased joint ROM
- Accelerating healing
- Pain control
- Edema control
- Bone and nerve healing
Rationale for Use of Diathermy

- Two therapeutic effects
- Thermal and non-thermal

**Thermal effects**
- Current flows through the treatment area
- Able to produce a deep heat to tissues

**Non-thermal effects**
- Results from same electrical current as thermal effects
- Low intensity and pulsed duration
  - Does not allow the heating of the tissue
  - Does increase blood flow to the area
  - Increased oxygen and nutrient availability
  - Increases cell growth and division
  - Changes in the cell membrane to increase healing potential.
Non-Thermal Effects for Wound Healing (Pulsed Short Wave Diathermy)

- Increased cutaneous circulation
- Decreased inflammation
- Edema reduction
- Lymphedema reduction
- Accelerated wound healing
- Treatment wound related pain
- Decreased hematoma formation
Electrode Variations

Air Space Electrodes

Pad Electrodes

- Drum Electrode
Infrared Light

Ultraviolet C (UVC) Light
Photobiomodulation- Light Therapy

- A term that describes the regulating effects of light energy upon cellular components
- Photo energy is converted to chemical energy for a biological effect
Low Level Laser Therapy

• Low level laser therapy or, low intensity laser therapy (LLLT or LILT)

• AKA:
  – Cold laser therapy
  – Photobiomodulation
  – Monochromatic infrared light therapy
Light Emitting Diodes
Outcomes of LLLT

- A summary of research and case studies revealed that irradiation with LLLT:
  1. Reduces pain and inflammation
  2. Turns on synthesis and repair of DNA & RNA
  3. Expands collagen production
  4. Proliferates nerve growth and sprouting

- Continued
Outcomes (Continued)

5. Actuates neo-vascularization
6. Releases/discharges lymphatic congestion
7. Induces a host of enzymatic reactions
8. Enhances the immune system
9. Diminishes scar tissue and adhesions formation
10. Increases ATP productions and more
Anodyne Treatment
Ultraviolet (UV) Light Therapy
Ultraviolet in Wound Care

• Ultraviolet (UV) radiation, a component of sunlight, has been used since the dawn of primitive man

• Antimicrobial effects have been recognized more recently
UV Light

- 1800s bactericidal properties of light discovered
- Early 1900s UV light discovered to be bactericidal to specific bacteria
UVC

- Adjunctive therapy for reducing and eliminating bacterial bioburden
- Consider as method for treating surface bioburden where conventional methods have failed
- Effective and safe for:
  - Combating a developing surface infection
  - Use with infected wounds where poor circulation reduces effectiveness of systemic antibiotics
  - Replacement for topical antibiotics
  - Treating antibiotic resistant species such as MRSA
UVC

- Beneficial effects for producing a mild inflammatory response to help accelerate wound healing
- UVC light is not intended as a prophylaxis, or as a replacement for appropriate infection control measures
- UVC light therapy compatible with any concurrently administered systemic antibiotics
- Treatment is consistent with wound care best practice guidelines
UV Light Properties

- UV light is a component to sunlight that encompasses wavelengths between 180 & 400 nanometers
- 3 spectral bands
  - UVA – produces most of the tanning effects
  - UVB – produces skin erythema, blistering and considered more carcinogenic
  - UVC – ionizing, bactericidal, virucidal
- UVC is the light spectrum focused on for its:
  - bactericidal effects
  - Wound healing stimulation due to an aseptic inflammatory response in tissues
## Bactericidal Effects of UVC Light

<table>
<thead>
<tr>
<th></th>
<th>Exposure time to kill 99.9%</th>
<th>Exposure time to kill 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S. Aureus</strong></td>
<td>5 seconds</td>
<td>45 seconds</td>
</tr>
<tr>
<td><strong>MRSA</strong></td>
<td>5 seconds</td>
<td>90 seconds</td>
</tr>
<tr>
<td><strong>S. Pyogenes (group A strep)</strong></td>
<td>4 seconds</td>
<td>Not eradicated with 180 second exposure</td>
</tr>
<tr>
<td><strong>VRE</strong></td>
<td>5 seconds</td>
<td>45 seconds</td>
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</tbody>
</table>
Treatment Protocol for Infected Wounds

- Prepare periwound area with drape or UV blocking lotion of at least SPF 30
- Protect patient and clinician with UV-protective eyewear
- Place UVC lamp ~ 1 inch (2.54cm) from wound surface
- Irradiate wound for at least 30 seconds
- Treat daily if wound highly colonized or infected with an antibiotic susceptible bacteria
- If wound infected with MRSA, treat 90 seconds daily
- If wound infected with antibiotic resistant E Faecalis treat 45 seconds daily
- Group A strep alone treat 4 seconds daily
- Strep A plus S aureus increase to 120 seconds daily
Electromagnetic Fields References


References – Light Effects on Human Body Vascular and Wound Healing

Light and Vascular Effects

- Furchgott RF and Jothianandan; Endothelium-dependent and independent vasodilation involving cyclic GMP: relaxation induced by nitric oxide, carbon monoxide and light; Blood Vessels; 1991, 28(1-3): 52-61

Light and Wound Healing Effects

Photo Therapy References

• Schindl M, Kerschan K, Schindl A, Schon H, Heinzel H, Schindl; Induction of complete wound healing in recalcitrant ulcers by low-intensity laser irradiation depends on ulcer cause and size; Photodermatol Photoimmunol Photomed; 1999 Feb; 15(1):18-21
• Campbell SS, Murphy PJ, Extraocular Circadian Phototransduction in Humans – Science 1998 January 16; 279: 396-399
• Morison J, Ovington L, Wilkie K. Chronic Wound Care: A Problem-Based Learning Approach; pp. 143-147, Mosby 2004
• Huseyin D, Balay H, Kirnap M: A comparative study of the effects of electrical stimulation and laser treatment on experimental wound healing in rats. JRRD Vol 41, Number 2, pp 147-154
• Sheffield, P, Smith A, Fife, C. Wound Care Practice, Chapter 32, Physical Therapeutic Modalities in Wound Healing, pp 607-630
Ultraviolet Light Therapy References

- Sheffield, P, Smith A, Fife, C. Wound Care Practice, Chapter 32, Physical Therapeutic Modalities in Wound Healing, pp 607-630
Mechanical & Acoustic

- Whirlpool
- Ultrasound
  - High frequency ultrasound=1-4 MHz
  - Low frequency ultrasound=20-120 kHz
Ultrasound in Wound Healing

- Ultrasound is a mechanical vibration of sound waves above the upper limit of human hearing
- Causes tissue molecules to oscillate or vibrate
- US has been used in wound care for over 50 years
<table>
<thead>
<tr>
<th></th>
<th>Traditional US High-frequency</th>
<th>Low Frequency Non-contact</th>
<th>Low Frequency Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>1 or 3 MHz, pulsed 20% duty cycle</td>
<td>40 kHz, continuous</td>
<td>22.5-35 kHz Continuous or pulsed</td>
</tr>
</tbody>
</table>
Traditional Ultrasound

- The physiological effects include:
  - ↑ mast cell degranulation
  - ↑ vascular permeability
  - ↑ release of mitogenic growth factors
  - ↑ migration of macrophages and fibroblasts
  - ↑ capillary density
  - ↑ calcium up-take in fibroblasts
  - ↑ collagen synthesis
  - ↑ tensile strength and elasticity of collagen

- Treatment is provided 3-5x/week, 1 minute for each cm² of treatment area, not to exceed 15 minutes.
Indications for LFU

- Locally infected wounds
- Wounds with impaired circulation
- Wounds with the need for debridement, irrigation, and topical treatment
- Pressure, diabetic, arterial and venous ulcers, post traumatic and surgical
Bacterial Killing by Low-Frequency Ultrasound
Staph. aureus - NLFU Treatment

After 2.5 minutes – 40k Magnification

Non Contact Low-Frequency US (NLFU)

- Unstageable PrU acquired in LTC
- 100% necrotic
- Treatments
  - NLFU + NPWT
- Outcomes
  - 74% area ↓
  - 97% granulation tissue ↑
56 y.o. ♀ Venous Ulcer LLE

- 2 year HX of re-occurrence
- Prior TX with standard care for VLU
- 48 hrs enzyme debridement - burning
- 4% Lidocaine® gel applied for 20 min.
- 25 kHz US debridement
- Absorbent dressing, S-S bandage

48 hours of enzyme debridement

After two 5-min. debridement sessions with 25 kHz US
<table>
<thead>
<tr>
<th>Low Frequency (kHz) Ultrasound</th>
<th>FDA 510k Indications / Labels</th>
</tr>
</thead>
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<tr>
<th>SonicOne™ Misonix, Inc.</th>
<th>Sonoca 180™ Soring, Inc.</th>
<th>Qoustic Wound Therapy System™ Arobella Medical</th>
<th>MIST™ Celleration® Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound Debridement Surgical fragmentation and aspiration of soft and hard tissues.</td>
<td>Selective dissection and fragmentation of tissue at the operation site</td>
<td>Selective dissection &amp; fragmentation of tissues, wound debridement &amp; cleansing of the site for removal of debris, exudates, fragments and other matter through the use of ultrasonic energy and/or fluid irrigation.</td>
<td>Promotes wound healing through: cleansing and maintenance debridement by removal of slough, fibrin, tissue exudates &amp; bacteria</td>
</tr>
<tr>
<td>22.5 kHz</td>
<td>25.0 kHz</td>
<td>35.0 kHz</td>
<td>40.0 kHz</td>
</tr>
</tbody>
</table>
Ultrasound References


- Morison MJ, Ovington LG, Wilkie K; Chronic Wound Care: A Problem-Based Learning Approach; By Mary Dyson, pp 129-141, Mosby, 2004


Negative Pressure Wound Therapy
Negative Pressure Wound Therapy (NPWT)

• Common Definition:
The controlled application of subatmospheric pressure to a wound to intermittently or continuously convey pressure through connecting tubing to a specialized wound dressing to promote healing\(^1\)
Proposed Mechanism of Action

- Provide moist wound environment
- Edema reduction
- Increase in perfusion
- Decreased bioburden
- Microdeformations: stimulation of granulation tissue formation
- Removal of wound exudate
  - Decrease in bacterial colonization
- Enhanced epithelial migration

Negative Pressure Devices
NPWT References

Pulsatile Lavage with Suction
PLWS

- Used by physicians high PSI since early 1980’s in O.R.
  - Irrigation in surgical procedures
  - Cleanse wounds of debris
- Used by physical therapists low PSI since late 1980’s
  - Irrigation and debridement to enhance healing of soft tissue wounds
PLWS

- Theory and Science of Therapy
  - Cleansing via gentle pulsatile lavage to stronger irrigation and debridement
  - Reduces bacteria and infection - Keblish, DeMaio
  - Promotes angiogenesis - granulation and epithelization - Haynes et al
  - Theory: negative pressure of suction stimulates cells and granulation - Argenta, Morykwas
BURN – OUT PATIENT
Pulsatile Lavage with Suction

- Eliminated need for whirlpools except in limited circumstances
- NOTE: WP contraindicated for CVI and DFUs

Courtesy Dr. Harriett Loehne
What Do You Need the Energy to Do?

- **Debride**
  - Contact LFU
  - Non-contact LFU

- **Decrease Bioburden & Chronic Inflammation**
  - ES
  - PLWS
  - LFU
  - Photo Therapy
  - NPWT

- **Decrease Edema**
  - Compression
  - NPWT

- **Facilitate Stalled Wound Healing Processes**
  - ES
  - LFU
  - Diathermy
  - Photo Therapy
  - NPWT
Who Should Apply These Energies

- Should be directed by and under the supervision/management of a skilled licensed professional **educated and trained in safe and effective selection, application, and monitoring methods**
Thank You