UPDATES IN WOUND MANAGEMENT

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OBJECTIVES:

1. Contrast differences of acute and chronic wounds.

2. Identify wound treatment modalities appropriate for type of wound.
Overview

- Wound classification
- Phases of healing
- Factors affecting healing
- Current treatment modalities
  - Topical
  - Hyperbaric O2
  - Extracellular matrix
  - Negative pressure
  - Electromagnetic/ Ultrasound Therapies
  - Pulsed Irrigation
Wound Classification

Why is this important?
- Drives treatment plan and expected outcomes
- Length of time to heal
- Preventing and treating factors affecting wound healing

A wound is a result of the disruption of the normal structure, skin function and skin architecture. A chronic wound does not progress through the normal stages of healing.

# Classification of Wounds

## Degree of Contamination
- **Clean**
  - Uninfected; no inflammation; no involvement of the GI, respiratory, GU tract, genitals
- **Clean contaminated**
  - Open, surgical or traumatic with inflammation; break in sterile technique
- **Contaminated**
- **Infected**
  - Old, traumatic, necrotic, purulent infection

## Other Factors in Classification
- **Acute vs. chronic**
- **Depth of injury: full vs. partial**
- **Skin integrity**
- **Cause of injury (intent)**
- **Type of injury**
  - Contusion, puncture, laceration, incision, pressure, abrasion, crush
Classification of Decubitus Ulcers

- Stage I: skin intact, pink
- Stage II: injury to dermis, epidermis, blister
- Stage III: injury into subcutaneous fat, full thickness
- Stage IV: muscle and bone involvement, necrosis
- USA: Un-staged eschar and Suspected deep tissue injury classifications

www.npuap.org/resources/educational-and-clinicalresources
Classification?
Infected- necrotic, osteomyelitis
Chronic
Depth- Full thickness
Skin integrity- compromised
Cause- accidental
Type- frostbite

Treatment: partial amputation with flap closure, bone biopsy and referral to ID.
Wound Healing Classification

- **Primary intention**: All layers are closed, rapid healing time, edges approximate.
  - Less scar, less risk of infection

- **Secondary intention**: Closed deep layers, open superficial layers.
  - Tissue loss, infection, increased scarring

- **Tertiary intention**: Open wound with delayed closure and healing.
  - Moderate risks infection and scarring
Phases of Wound Healing

I. Inflammatory: Hemostasis and inflammation

- Begins immediately and lasts up to 3 days, coagulation cascade, vasoconstriction, platelets aggregate, fibrin clots.
- Neutrophils attack bacteria
- Macrophages are transformed for cell repair and stimulation of fibroblast division, collagen synthesis and angiogenesis
- Key components of this phase include increased vascular permeability and cellular recruitment, including secretion of vimentin, as structural protein for wound healing.
- Chronic wounds typically arrested in this stage due to abnormal production of MMPs impairing function of cytokines to digest bacteria and necrotic tissue.

Phase II: Proliferative

- 3 days to 6 weeks
- Macrophages stimulate migration of fibroblasts into the wound for secretion of collagen type III and elastin
- Collagen needed for tensile strength
- Formation of granulation tissue to replace fibrin/fibronectin
- Extracellular matrix deposition and wound contraction begins
- Process impaired by biofilm and bacteria that promote inflammation and impair epithelialization. [www.uptodate.com](http://www.uptodate.com) 2026
Phase III: Maturation

- Week 3 up to year for scar remodeling
- Fibroblasts continue to synthesize collagen and proteoglycan for the wound bed to increase tensile strength.
- Collagen III converts to collagen I which increases tensile strength up to 80% by week 6.
- Collagen cross-linking, remodeling, wound contraction and re-pigmentation.


Factors Affecting Wound Healing

- Acute vs. Chronic
- Infection
- edema
- Impaired circulation
- Impaired mobility
- Impaired nutrition
- Infection
- Smoking

- Diabetes
- Obesity
- Chronic lung disease
- Previous infection
- Liver or kidney disease
- Immunosepression
- Drugs affecting inflammatory or clotting response

Meddean, 2008.
Hematoma and Osteomyelitis
CHRONIC WOUNDS

Wounds that do not heal in a timely or complete progression will have:

- Increased inflammation
- Increased pro-inflammatory cytokines
- Increased proteases (MMP: metalloproteins)
- Decreased response of fibroblasts to growth factors

EXAMPLES: diabetic ulcer, vascular ulcers, Decubitus ulcers

Goals of Wound Healing

- Repair tissue in a timely manner
- Restore function and anatomy
- Prevent infection
- Minimize inflammation and edema
- Minimize pain
- Best possible aesthetic outcome
First Stage of Healing A Complicated Wound
Basic Principles & Standards of wound Management

- Debride necrotic tissue
- Remove excess wound exudate
- Decrease bio-burden; all are colonized, but not all infected
- Eliminate pressure
- Control edema and inflammation
- Prevent infection
- Wound closure as quickly as possible
Choosing the Best Dressing

<table>
<thead>
<tr>
<th>Dressing Goals</th>
<th>Patient considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eliminate dead space</td>
<td>Comfortable/reduce pain</td>
</tr>
<tr>
<td>Control and/or absorb exudate</td>
<td>Ease of application and removing/location</td>
</tr>
<tr>
<td>Prevent buildup of biofilm and bacteria</td>
<td>Control odor</td>
</tr>
<tr>
<td>Maintain adequate moisture without maceration</td>
<td>Portable/orthotics</td>
</tr>
<tr>
<td>Prevent leakage onto healthy tissues</td>
<td>Length of wear time/moisture</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
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<td></td>
<td>Sensitivity</td>
</tr>
</tbody>
</table>
The Perfect Dressing

- Conforms to wound shape and eliminates dead space
- Pain free
- Removes exudate and contains drainage
- Easy to apply and remove
- Prevents and removes bacteria
- Debrides necrotic tissue and fibrinous slough
- Low cost and available
- Prevents maceration of wound edges
- Does not leave material behind or shred within a tunnel
- Does not require frequent changes
- Provides compression where needed
- Does not cause dermatitis
PERFECT DOES NOT EXIST

- There is not enough clinical evidence to assist the provider in choosing one dressing over another.
- General accepted consensus based on what is available
- Hydrogels for debridement stage
- Foam and low-adherence dressings during granulation stage
- Hydrocolloid and low adherence dressings for epithelization stage
- Advanced therapies as individually indicated
- Antimicrobials as needed; not prophylactic
Traditional Therapies: Updates

- **Hydrogels**: promote autolytic debridement and hydration.

- Silvasorb gel: hydrophilic gel with ionic silver

- Silvasorb sheet: up to 7 day dressing changes

- TheraGuaze: polymer that will absorb or release moisture as needed

- **Wet to dry**: Tenderwet
  - Gentle autolytic debridement
  - Hydrogel dressing for cavities
Traditional Therapies: Updates

- **Collagenase**: dressing, ointment or powder

- Promogran Matrix has 55% collagen and can be used in exudating wounds

- Prisma Matrix: low silver content for antimicrobial action.
  - Absorbs exudate
  - Binds to and inactivates MMPs which prevent wound healing
  - Santyl: 250 units per gram of collagenase in petrolatum

- Fibracol Plus: 90% collagenase and 10% alginate
  - Option for draining wound
Collagenase

- **Triple Helix** by MPM Medical: 100% bovine collagen
  - Biodegradable in wound
  - Comes in powder form or sheets

- **Endoform**: 90% collagen and 10% intact ECM components that provide a broad spectrum reduction in MMPs in chronic wounds.
  - Weekly application.
  - Not a prior authorization item, considered a dressing
Traditional Therapies: Updates

- **Alginates:** Thicker with better absorption
  - Reinforced, available with silver, rope for tunnels, **not** water soluble
  - Foam dressings with silicone adhesive; more site conforming options
  - Aquacel surgical hydrofiber dressing with flexible hydrocolloid adhesive dressing; polyurethane film is waterproof with a viral/bacterial barrier
    - Silvercel
    - Maxsorb
    - Restore
    - PolyMem
Foam Dressings

- Multiple brands and shapes
- With and without silver
- Two layer construction with an absorbing hydrophilic layer and hydrophobic layer to prevent leakage and bacterial entering the wound.
- Silicone adhesive is skin friendly
- Multiple day wear
- Some pressure relief
HydroActive Dressing

- Newest synthetic dressings
- Combines properties of a gel and a foam dressing
- Selectively absorbs excess water/drainage and leaves behind the needed growth factors and proteins to heal a wound.
- Can combine with enzymatic debriding agents
  - HydroTac
  - PermaFoam
  - Sorbact
  - Duoderm hydroactive dressing
Hydroconductive Dressings

- **Drawtex**: 2011 on the market.
- **Non-adherent LevaFiber technology**
- Combines 2 types of absorbent, cross-action structures that facilitate the movement of large volumes of drainage and wound debris through the dressing. [Couch KS. Discovering hydroconductive Dressings. Ostomy wound management, 2012; 58(4): 2-3.](#)
- **Results**: decrease bacterial level and nutrients for biofilm production, decrease MMPs and cytokines, facilitate wound bed preparation, minimize exudate
Hydroconductive Dressing

- Can be used in place of NPWT with skin grafts
- Pilonidal sinus tracts
- Burns
- May double the layers for heavy drainage
- Consider non-adherent dressing underneath superficial, but draining wounds
Honey

- Resurgence of honey for autolytic debridement, re-hydration and antimicrobial actions

- High concentrations of hydrogen peroxide and high osmolarity result in broad spectrum antimicrobial activity

www.uptodate.com 2016

- Careful for sensitivity reactions

- Gel, strips, pads

- Insufficient data to make scientific recommendations
Closed Pulse Irrigation

- Direct, localized hydrotherapy in a closed, contained system using a pulsatile pressurized stream of normal saline.

- In place of sharp debridement

- Not painful, minimal bleeding

- Decreases bacteria

Benefits of Pulsed Irrigation

- Can be done daily, decreases pain, accelerates healing
- Performed by nurses in the clinic, home or rehab setting
- Use in conjunction with NPWT
- Use in wound tunnels with special tips, 8-15 PSI
- CPT codes 97597 (up to 20 sq. cm) and 97598 used for reimbursement by providers
- Must use closed system to contain aerosols and infectious disease risks: MDRO outbreak @ John’s Hopkins
New Irrigation techniques

- Combine pressurized water irrigation with ultrasound
- Portable for clinic use
- Multiple tips for varying pressure and area treated
- Minimal collateral tissue damage
- No nerve damage
Negative pressure Therapy

- Vacuum assisted wound closure
- Continuous or intermittent -50 to -175mmhg subatmospheric pressure applied evenly to the wound surface
- Used in tunnels, skin grafts post-op
- New disposable, smaller models (PICO) by Smith & Nephew
- Fluid installation adjunct treatment
- Fluid removal and reduction in healing in time with moist environment and drawing edges together
- Incisional NPWT...sutureless closure on the horizon
Negative Pressure Therapy

**Indications:**
- Slow, stagnant wounds that fail conservative treatments
- Heavy exudate
- Tunneling
- Require size reduction for surgical closure
- Skin grafts, 1 or 2 stage

**Contraindications:**
- Malignancy
- Untreated osteomyelitis
- Necrotic tissue or eschar
- Exposed vasculature, nerves, organs, anastomotic sites, unexplored fistulae
NPWT Precautions

- Friable, bleeding tissue
- Exposed tendon, delicate fascia or ligaments
- Enteric fistulae require special precautions
- Bony fragments, infection, vascular anastomoses, spinal cord injury

NPWT Treatment Benefits

- Control exudate, increase blood flow
- Reduce risk of infection
- Reduce number of dressing changes
- Reduced wound odor
- Can be done in the home
- May reduce pain
- Prepare wound bed for surgical closure
## Foam or Gauze NPWT?

<table>
<thead>
<tr>
<th>Gauze</th>
<th>Foam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimicrobial standard</td>
<td>Silver foam must be requested</td>
</tr>
<tr>
<td>Typically less painful and easier to remove</td>
<td>No drain choice, less fluid removal</td>
</tr>
<tr>
<td>Flat, round or channel drain</td>
<td>Less timely application and caution in tunnels</td>
</tr>
<tr>
<td>Easier and faster to apply and remove</td>
<td>Granulation adherence can cause painful removal and disrupt wound bed</td>
</tr>
<tr>
<td>More “confident” removal in tunnels</td>
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</tr>
</tbody>
</table>
NPWT Treatment Considerations

- Wound location; bridge
- Tubing placement and pressure settings
- Wound bed preparation
- Size and number of wounds, frequency of changes
- Patient expectations, mobility, cognitive and sensory function, social environment and lifestyle

Complex Wound

Consider co-morbidities
Difficult placement
Risks of infection and osteo
Nursing skill
NPWT: Are We There Yet?

- Patience with our patients
- Uniform granulation and depth of wound
- Stalling measurements
- Bleeding
- 3 month “rule”
- Pain or intolerance of the device
- Drainage
NPWT ENDPOINT

Beefy red granulation tissue

Cavity and tunnel filled in
Minimal drainage

No bony or tendon exposure

Wound bed prepared for skin grafting coverage…keep that NPWT
Human extracellular matrix (ECM) is the structural complex that surrounds cells and binds to tissue. In chronic wounds, the body’s naturally occurring ECM is failing. In healthy skin, ECM makes up the key components of the basement membrane that anchors and replenishes epidermal cells, guides, stimulates cell proliferation and migration to assist in modulation of cellular response. Macneil S. *What Role Does the ECM Service I Skin Grafting and Wound healing?* Burns. 1994; 20(supplement): S67-70.
ECM

- Construct of collagen to act as a scaffold for growth of tissues
- Complex, 3 dimensional, organized structure
- Important to all stages of healing
- Collagen types 1 & 3 are the structural proteins for strength and integrity of skin
- Elastin protein provides elasticity
- Cell adhesive glycoproteins are the modulators for growth factor activity by binding to surface integrin receptors
- Matrix cellular proteins help regulate inflammatory response, keratinocyte migration for maturation and contraction of ECM.
ECM and Chronic Wounds

- In chronic wounds, fibroblasts are unresponsive to growth factors and other signals. These wounds lack the integrin receptor for fibronectin binding and keratinocyte migration. Davin-Haraway, G. [WWW.hpmcommunications.com](http://WWW.hpmcommunications.com)

- ECM triggers neovascularization and recruits cells that differentiate into site specific tissues. When ECM allograft is absorbed, it leaves functional tissue which becomes scar tissue.

ECM Allografts

- Multiple types and specific indications
- Partial and full thickness wound, donor sites
- Porcine, neonatal foreskin, amniotic membrane
- Powder, sheets, multi-layers
- Refrigeration or open storage
- Require prior authorization and specific detailed application notes
- Absorbed and incorporated into the wound
Common ECM Products

- Epicel- cultured epidermis
- Integra- 2 layered, bovine collagen and outer silicone
- AlloDerm- human cadaver
- Biobrane- porcine collagen and semipermeable silicone membrane
- Dermagraft- allogenic human fibroblasts on bioabsorbable scaffold
- Apligraf & OrCell- allogenic neonatal foreskin with keratinocytes, fibroblasts, bovine collagen
- Acell- porcine small intestine matrix
# ECM Application

## Clinical Considerations
- Prepared wound bed
- Type of wound
- Edema
- Amount of drainage
- Documented failed standard wound treatments
- Secondary dressing
- Follow up/multiple applications

## Contraindications
- Infection
- Ovine, Porcine allergy or kosher
- Apligraf FDA approved for diabetic and venous ulcers
- Oasis and Acell indicated for all wound types except 3\textsuperscript{rd} degree burns
- Single use only
ECM: Considerations for Treatment

- Multiple, weekly applications
- Control edema and drainage
- Use of NPWT if needed
- Control bio-burden and infection
- Pressure relief and ambulation
- Odor
- Skilled dressing changes
- Endpoint: wound closure, lack of progress
Oxygen Therapies

- Transdermal/continuous diffusion oxygen (CDO), topical hyperbaric (THO), hyperbaric oxygen (HBOT)

- Therapeutic and technologically differences

- HBOT oldest and most accepted form

- CDO newest approach with growing evidence, less reported risks and side effects, due to lower flow rates and lack of pressure.
Hyperbaric Oxygen

- Since 1600’s, systemic application 5-7 days per week for 90 minutes in a chamber, intermittent

- Adjunct to wound healing therapies

- 100% O2 delivered under increased atmospheric pressure greater than 1 atmosphere, up to 3

- Goal: raise the O2 levels within the wound bed to correct hypoxia in chronic wounds

- New standards developing for acute burns, surgical flaps and grafts
Hyperbaric Oxygen: Therapeutic Effects

- Reverse local tissue hypoxia
- Increase stimulation of collagen synthesis
- Improved rate of bacterial killing
- Diminish inflammatory signals

Issue: Few controlled trials, different wound types and outcome parameters, but overall, demonstrated improvement in healing

Approved Wounds for HBOT

Diabetic lower limb ulcers
Chronic, refractory osteomyelitis
Necrotizing fasciitis
Acute peripheral arterial insufficiency
Compromised surgical flaps and skin grafts
Actinomycosis
Soft tissue radionecrosis and osteoradionecrosis
Crush injury/acute traumatic peripheral ischemia
Complications of Hyperbaric Therapy

- Middle ear trauma and effusions
- Sinus barotrauma (sneeze)
- Reversible myopia
- Pulmonary toxicity
- Seizures
Topical Hyperbaric Oxygen

- Since 1960’s
- Affected area in a boot, bag or extremity chamber which is sealed and filled with O2 at high flow rate for O2 rich environment
- 5-7 days per week for 90 minutes to 4 hours, intermittent
- Low pressures and therefore lower risk of side effects
- Requires an open wound surface, not used for necrotic or sinus tracts
- Noted to increase angiogenesis and wound closure rates
Continuous Diffusion of Oxygen Therapy

- Newest class

- Provide continuous O2 delivery at lowest flow rates

- Portable, smaller, increase access, lower cost

- Also called low-flow or transcutaneous O2, continuous

- 7 days per week, 24 hours, 3-12 ml/hr O2 delivery

- Not applicable in wounds with eschar or sinus tracts

- Improves granulation tissue, increased collagen and epitheliazation
Biologically Active Wound Stimulation Therapies

- Electrical Stimulation
  - Bio-electric Dressing

- Ultrasound Assisted Wound Therapy
  - Mist Therapy and Electromagnetic Therapy
    Modalities to reverse the current of injury; loss of the 40-80mV negative charge of the epidermis relative to the deeper tissues that carry a positive charge, when a full thickness injury occurs.

Basic Concepts of E-Stimulation

- Loss of intact skin = change in charge gradient between the skin and the deeper tissues

- A micro-current will flow from the area of the intact skin into the wound; voltage peaks and decreases as the wound heals.

- In chronic wounds, the current flow is defective and healing stalls.

- E-Stim re-applies this current to stimulate healing via direct, alternating or pulsed currents
Electrical Stimulation

- **Treatment**
  
  Pressure ulcers, leg ulcers

  High or low voltage

  45 minutes 3-5 days per week

  Angiogenesis is enhanced by improving capillary dermal formation

- **Effect on Healing**

  - Inhibit bacterial growth and disrupts biofilm
  
  - Increases keratinocyte migration
  
  - Increases fibroblast protein synthesis, collagen production and organization of collagen fibers
Bio-Electric Dressing

- Woven polyester fabric surface with a matrix of bio-compatible silver and zinc dots, 1 or 2mm

- A secondary moist dressing is placed to maintain moisture level and promote a micro-current of 0.6 to 0.7 volts

Ultrasound Assisted Wound Healing

- First appeared in the literature in 1949

- Therapeutic ultrasound delivers energy in the form of sound waves from mechanical vibrations; similar to diagnostic imaging waves

- Low frequency, provides non-thermal effects of cavitation and acoustic streaming

- The shock waves will liquefy necrotic tissue, wound debris and biofilm without injury to healthy tissue with greater tensile strength

- NOW: combining with water irrigation
Ultrasound Assisted Wound Therapy

- **Wound Indications**
  - Local infection, not systemic
  - Vascular disease
  - Pressure ulcers
  - Diabetic foot and LE ulcers
  - Wounds needing debridement

- **Contraindications**
  - Systemic infection
  - Advancing cellulitis
  - Joint replacement or local hardware
  - Implanted electronic devices within the treatment field

[www.todayswoundclinic.com](http://www.todayswoundclinic.com)
MIST ULTRASOUND THERAPY

Low frequency ultrasound delivers atomized saline spray into acute wounds

Saline acts as a conduit from the US to the treatment site and promotes healing by cleansing and maintaining wound debridement

Studies have not substantiated this and research is needed

Keltie, K. et al
Electromagnetic Therapy: Sub-thermal PSWD

- Pulsed shortwaves produce electromagnetic fields believed to enhance healing
- Pulsed wave energy is absorbed in wet, ionic, less dense tissues: muscle and nerves
- Diminishes inflammation and increases repair of musculoskeletal and soft tissues through increased membrane transportation that restores ionic balance with energy absorbed
- Can be electric or magnetic short wave therapy, but most literature focuses on magnetic
Primary Effects on Wound Healing

- Increased white cells and fibroblasts = decreased inflammation
- Promote fibrin and collagen deposition and layering
- Increases protein and nerve growth factors

Contraindications

- Pacemakers
- Pregnant females
- Bleeding tissues
- Malignancy
- Active TB
- Ischemia or thrombosis
- Radiated tissue
Wound Stimulation Therapy Limitations

- Multiple machines
- Multiple energy outputs
- Lack of treatment parameters: dosage, timing
- Lack of research studies
Topical Growth Factors

- **Becaplermin** (Regranex): platelet derived growth factor gel that promotes cellular angiogenesis to improve wound healing.

- Approved for diabetic foot ulcers and chronic wounds

- Black box warning for malignancy, noted to be with increased use

- **GM-CSF**: granulocyte-macrophage colony stimulating factor is and intradermal injection to promote healing in chronic leg ulcers. Being studied in chronic wounds.

- **Epidermal Growth Factor**: studies on treating chronic venous ulcers
Future Studies

Growth factors

- platelet derived (PDGF-BB)
- VGF: vascular endothelial derived
- basic fibroblast
- granulocyte-macrophage colony stimulating factors
- Drugs to improve vasodilation and blood flow

Stem cell therapy

- bone marrow
- Adipose tissue
- muscle tissue

Gene therapy

- Specific genes to target specific cells
- Improve, alter or negate a cell function and genetic coding once the gene is incorporated into the cell
- Includes growth factors, receptors, adhesion molecules and protease inhibitors.
- Gene activated matrix

- Wii-ping, Linda Fan, 2010
References


National Pressure Ulcer Advisory Panel: Updated Staging System, 2007

www.pulsecaremedical.com


References


- Mechem, c. and Manaker, s. Hyperbaric Oxygen Therapy. www.uptodate.com