Wound Healing: A Practical Approach

Kevin Sexton

Bonus Conference 5/2/12
Goals

1) To list the phases of wound healing and have a basic understanding of each.

1) List the types of wound closure and components of the reconstructive triangle.

2) Be exposed to current wound dressings/therapies.
Why bother?

• 6.5 million chronic wounds in the US

• 4 Main Types
  - Pressure sores
  - Diabetic ulcers ($38 billion dollars in 2007)
  - Venous stasis ulcers
  - Arterial insufficiency

• Americans are getting older


Wound Classification

• Acute
  – < 3 months old

• Chronic
  – > 3 months old
  – Problem with inflammation
All may occur simultaneously

Individual Processes
May Overlap
What are the primary cells responsible for each wound healing phase?
How strong is the wound?

- 1 Week →
- 3 Weeks →
- 12 Weeks →
- 16 Weeks →

What are you going to tell your patients about activity?

Wound Closure

• Primary
  – First intention
  – Immediate Closure
  – Suturing, skin graft placement, flap closure, etc

• Secondary
  – Wound is allowed to close spontaneously
  – Highly contaminated wounds

• Tertiary
  – Delayed primary closure
  – Control infection $\rightarrow$ $\rightarrow$ Wound Closure
Figure 8-1  Wound closure types. **Top**, Primary or first-intention closure. A clean incision is made in the tissue (A) and the wound edges are reapproximated (B) with sutures, staples, or adhesive strips. C, Minimal scarring is the end result. **Bottom**, Healing by secondary intention. The wound is left open to heal (A and B) by a combination of contraction, granulation, and epithelialization. C, A large scar results.
The Reconstructive Triangle

- Flaps / Grafts
- Tissue Expansion
- Microsurgery
Wound Care

• 3 Healing Gestures
  – Washing the wound
  – Making Plasters

• Topicals to aid in wound healing
  – Bandaging the wound

Carved into a stone tablet dated 2200 BC

Modern Wound Therapy

• Prepare the wound bed
  – Minimize hypoxia
  – Minimize bacterial content

• Create a warm, damp occluded environment
  – Maximizes epithelialization
  – Minimizes pain

• Disrupt the environment as little as possible

• Minimize the impact of comorbidities
Oxygen Delivery

• Wound ischemia is detrimental to all processes
  – Initial factor for chronic wounds
• Relative hypoxia more common
  – Initially stimulates fibroblast proliferation and angiogenesis
  – Higher oxygen tension is required thereafter
Relative Hypoxia

- PaO2 of 30-40 mm Hg of O2
  - No fibroblast replication
  - Collagen production severely limited

Treatment Options

• Angioplasty
• Bypass
• Minimize comorbidities
  – Stop Smoking
  – Therapy for heart failure
Blood Transfusions

If relative hypoxemia is bad, then a low hemoglobin concentration must impair wound healing.

Actually, if compensatory mechanisms maintained (cardiac output, adequate pulmonary gas exchange, and normalizing lactate) then the data is equivocal.


Fig. 4. No correlation between collagen deposition on day 7 and hematocrit value was found. Data on day 5 were similar.
Infection

• Health is not sterility.
• Number of organisms present per gram of tissue
• $10^5$ organisms/gram tissue
  – $\geq$ chances of wound closure 20%
  – $\leq$ 94% chance of closure


Treatment Options

• Debridement
  Presence of foreign debris reduces number of bacteria to cause a wound infection by a factor of 10,000


• Antibiotics
  Systemic antibiotic are ineffective unless there are systemic symptoms

  Topical antibiotics deliver high concentrations of drug where they are most effective.

Dressings Qualities

- Protect wound from bacteria and foreign material
- Absorb exudate
- Prevent heat and fluid loss
- Provide compression
  - Minimize edema and dead space
- Be nonadherent to limit wound disruption
- Be aesthetically attractive
Occlusive Dressings

- Winter Experiment
- Rate of epithelialization doubled in wounds that were covered in occlusive dressing

Occlusion

- Damp, mildly acidic environment
  - Epidermal migration, angiogenesis, connective tissue synthesis
- Relatively lower oxygen tension
  - Stimulates angiogenesis
  - Good initially, bad if persists
- Granulation stimulated by cytokines
  - Preserved if wound environment occluded

Occlusion is Better than Sliced Bread.

Figure 2. Days to complete healing. Epithelialization was complete significantly faster when the synthetic adhesive moisture vapor permeable and fine mesh gauze dressings were used.

There are no perfect dressings.

- Infected wounds
  - Need non-occlusive dressing
- Heavily Exudative wounds
  - Need absorbent dressing
- Necrotic Wounds
  - Need debriding dressings
But there are a lot of choices

<table>
<thead>
<tr>
<th>Types of dressings</th>
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<tbody>
<tr>
<td>Nonadherent fabrics</td>
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<tr>
<td>Absorptive</td>
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<tr>
<td>Gauze</td>
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<tr>
<td>Foams</td>
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<tr>
<td>Occlusive</td>
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<tr>
<td>Nonbiologic</td>
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<tr>
<td>Films</td>
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<tr>
<td>Hydrocolloids</td>
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<tr>
<td>Alginites</td>
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<tr>
<td>Hydrogels</td>
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<td>Biologic</td>
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<td>Homograft</td>
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<tr>
<td>Xenograft</td>
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<tr>
<td>Amnion</td>
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<tr>
<td>Skin substitutes</td>
</tr>
<tr>
<td>Creams, ointments, and solutions</td>
</tr>
<tr>
<td>Antibacterial</td>
</tr>
<tr>
<td>Enzymatic</td>
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<tr>
<td>Other</td>
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</tbody>
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# Nonadherent Fabrics

<table>
<thead>
<tr>
<th>Hydrophobic</th>
<th>Hydrophilic</th>
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<tbody>
<tr>
<td>More Occlusive</td>
<td>Facilitate drainage of fluid into overlying layers</td>
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<tr>
<td>Xeroform</td>
<td>Adaptic</td>
</tr>
<tr>
<td>– 3% Bismuth tribromophenate in petroleum</td>
<td>– Fine mesh gauze</td>
</tr>
<tr>
<td>– Limited antimicrobial activity</td>
<td>– Staphylococcus aureus</td>
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<tr>
<td></td>
<td>– Escherichia Coli</td>
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<tr>
<td>Vaseline Gauze</td>
<td></td>
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<td>Telfa</td>
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Absorptive Dressings

Gauze

• Wide-Mesh
  – Kerlix
• Sticks to wounds
  – Debridement
• Overwrap
  – Wick moisture

Foam Dressings

• Hydrophobic, polyurethane foam sheets
  – Allevyn
  – Mepilex
  – Biopatch
• Absorbent
• Nonadherent
Occlusive Dressings

Non-Biologic
• Films
• Hydrocolloids
• Alginates
• Hydrogels

Biologic
• Allograft
  – Alloderm
• Xenograft
  – Strattice
• Amnion
• Skin Substitutes
  – Integra

Benefits of Both:
• insulation
• moisture retention
• mechanical barrier
Films

- Tegaderm
- Op-Site
- Waterproof
- Allow Gas Transmission
  - Oxygen
  - Carbon Dioxide
  - Water Vapor

- Nonabsorptive
  - Leak
- Need to have intact skin surrounding wound
Hydrocolloids

- Hydrocolloid matrix
  - Gelatin, pectin, carboxymethylcellulose
- Wafers, Pastes, Powders
- Duoderm
- Water contact leads to swelling and gel formation
Alginates

- Based on alginic acid (seaweed) derivatives
- Exudative wounds
- Forms gel with water contact
- Must change when begins to “bleed”
- Sorbsan
Antibacterial Solutions

• Acetic Acid
  – gram - coverage, Pseudomonas
  – 0.5% concentration for effect
  – 0.25% killed 100% of fibroblasts in vitro
  – Slows wound epithelialization
  – Decreased PMN function

• Dakins (bleach)
  – Non-descriminant killer
    • Wounds slower to epithelialize and neovascularize

Iodine Containing Solutions

• Kills bacteria
• For the most part, studies show betadine does not promote good wound healing and impairs wound strength.


Silver Dressings

• Broad antibacterial spectrum
• Silver sulfadiazine (1960’s)
  – Antibacterial, antifungal, antiviral
  – Neutropenia
• Sulfamylon (first used during WW II)
  – Can penetrate eschar
  – Inhibits carbonic anhydrase (metabolic acidosis)
• Both kill fibroblasts in culture, however they increase epithelialization and neovascularization in partial thickness wounds.
• Acticoat- only have to change every 3 days
Silver References

Antibacterial Ointments

- Gram Positives
  - Bacitracin, Mupirocin
- Gram Negatives
  - Neomycin, Polymyxin B
- Antibacterial effect for 12 hours
- Little benefit to epithelialized wounds
Vacuum Therapy

- Increased Granulation Tissue
- Increased Wound Blood Flow
- Increased Angiogenesis
- Decreases healing time
- Increased Bacterial Load in wound

Contraindications for V.A.C. Therapy

A. Patients with:
   1. Grossly Contaminated Wounds
   2. Malignancy in the Wound
   3. Untreated Osteomyelitis
   4. Non-enteric and Unexplored Fistula
   5. Necrotic Tissue with Eschar Present

B. Do NOT place V.A.C. GranuFoam (Black sponge) over exposed blood vessels or organs. May use VersaFoam (White) or petroleum-based gauze over exposed blood vessels or organs at base of wound with overlaying GranuFoam.