Wound Healing: How we do it.

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Medical Director
Fort Healthcare Wound and Edema Center
His whole life was a million-to-one shot.

ROCKY
Background: RJ Goldman, MD

- MD University of Texas, Galveston
- Rehabilitation Medicine Residency (Albert Einstein, Bronx, NY)
- NIH Fellow (University of Pennsylvania)
- Associate Professor, Rehabilitation Medicine (U of PA)
- Wound healing experience:
- University of Pennsylvania Health System (1996-2005)
- Rehabilitation Wound Clinic:
  - Developed Outpatient Wound Program
  - Treated all types of chronic wounds
  - Limb salvage
  - Electrotherapy (NIH Grant)
The financial burden of chronic wound care is immense: in the USA, the chronic wound care bill, including professional expenses, hospital costs, and complications (direct costs only), ranges from $7 billion to $15 billion. The costs for all chronic wound types are increasing at 10% per year, driven by the aging of the “baby boomers.” Four basic ulcer types present significant economic burden: pressure ulcers ($3–6 billion), ischemic and neuropathic ulcers ($3–5 billion), and venous ulcers (> $2 billion). Because prevention and aggressive treatment of early ulcers reduces costs, there is an economic impetus for growth of outpatient wound centers. In the past 20 years, the number of wound care treatment centers has risen from very few to about 700.1

Another trend in wound care derives from the current revolution in molecular biology, gene therapy, biomaterials, and stem cell research. Stem cells are now being applied to animal models of chronic wounds. Chronic wound products derived from recombinant DNA technology have been in place since the late 1980s.2 Possibly dramatic changes might occur from gene therapy involving growth factors, which are now entering human trials. Human trials involving artificial skin grafts2 have lead to Food and Drug Administration (FDA) approval for using such grafts with certain ulcer types. Physiatrists can potentially utilize all these interventions.

Physiatrists should be involved and involved in chronic wound care because of the high investment in optimizing the function of patients, managing rehabilitation teams, prescribing orthoses and modalities, and understanding gait biomechanics and protected weight bearing. All these are critical components of conservative or nonsurgical chronic wound care. This chapter elaborates the role of the physiatrist as ambulatory wound care consultant, promoting limb salvage and functional preservation.

SCAPE OF THE PROBLEM
Definitions
The National Pressure Ulcer Advisory Panel defines a pressure ulcer as an area of unrelieved pressure over a defined area, usually over a bony prominence such as the greater trochanter of the femur, sacrum, or ischium, resulting in ischemia, cell death, and tissue necrosis.5,4 Pressure ulcers are associated with impaired mental status or sensation, poor hygiene or nutrition, and multiple comorbidity factors. High standards of nursing and medical management are key to prevention of ulcers in immobilized patients.

Chronic venous or edematous ulcers of the leg typically arise on the gator area of the leg (i.e., the lower third of the leg). They are associated with impaired venous return, incompetence of venous perforators, or loss of fascial integrity of the leg (e.g., from trauma) in patients with normal arterial inflow. The cornerstone of treatment is compression. Neuropathic ulcers follow repetitive trauma to hyporesponsive distal extremities (e.g., feet), usually on weight-bearing bony prominences such as metatarsal heads. For uncomplicated neuropathic ulcers, the circulation is usually functionally intact.5 A cornerstone of treatment is mitigating abnormal axial repetitive pressure and shear.

Ischemic ulcers occur on limbs with impaired arterial inflow due to arteriosclerotic disease and, in the setting of diabetes, microvascular disease. Often initiated by minor trauma or shoe pressure on the medial or lateral foot margins, they are typically painful and blanched. Ischemic ulcers are frequently associated with neuropathy or edema. Healing of these ulcers primarily depends on reestablishing arterial circulation.

Epidemiology of chronic wounds
Persons with spinal cord injury (SCI) and associated comorbidity are at increased risk for the formation of pressure ulcers. In one community-based sample, the point prevalence of stage 3 or 4 pressure ulcers was 26%.6 The second population at risk for pressure ulceration is the elderly. The annual prevalence of pressure ulcers among those 65 years of age and older varies from 0.1% to 0.7%, and such ulcers are most likely to occur in patients 85 years and older.7

The prevalence of pressure ulcers of any stage for hospitalized patients ranges from 3.5%12 to 69%.1 (The latter prevalence decreased significantly, to 10%, after instituting a multidisciplinary approach to prevention and treatment on the surgical inpatient service at one hospital.) Patients in critical care units can run a higher risk of developing pressure ulcers, as evidenced by a 40% incidence in one study.8 Long-term facilities are frequently the disposition for patients with pressure ulcers sustained during acute hospitalization. In one very large study involving 51 nursing homes, 11.3% patients were admitted with stage 2 through stage 4 pressure ulcers.
Electrotherapy Reverses Inframalleolar Ischemia: A Retrospective Observational Study

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University of Pennsylvania
Home based electrotherapy improves healing of ischemic wounds: A phase I prospective study.

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Michael Golden\textsuperscript{2}, MD

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Wound care experience (continued)

- Visiting Faculty, University of Texas, Houston (2006)
- Wound care and Hyperbaric Oxygen Center
- Memorial Hermann Hospital
- Caroline Fife, MD, Director
- Supervised 1000 HBO treatments, wound care.
- Board certified, Undersea and Hyperbaric Medicine, 2010
Wound Care Update: Objectives

- List wound types: Similarities and differences
- Review wound healing principles
- Understand wound-specific standards of care.
Mary Carvalho, RN, BSN, MBA

- Clinical Coordinator, Fort HC Wound Edema Center.
- “Wound and skin assessments”
- Assess size and appearance of wounds
- “Interactive Wound Care Demonstrations”
Figure 2
Reduced bio-burden leads to healing

- Wound bed preparation
  - Invasive infection
  - Critical colonization (>100,000 CFU per gram tissue)
  - Colonization
- Debridement
- Rapid closure
Moist Wound Healing

- “not too wet, not too dry”
- Wound bed preparation
  - Highly absorbent dressings
    - Silver dressings, cadexomer Iodine
    - Antibiotics
    - Foam, Hydrogels
  - “Frequent” dressing changes.

Moist wound healing

- Healing phase
  - Less absorbant dressings, gels, much less antibiotics used
  - Infrequent dressing changes, e.g., weekly
- Lisa Reil, RN, speaker today on “Dressing types and when to use them”
Why check arterial flow for wound care?

- Venous stasis wounds: Establish safety of compression
- Arterial wounds: Localize segment of arterial disease
- All wounds: Establish prognosis for healing

Tissue Hypoxia

- Leads to the following alterations in normal healing:
  - ↓ inflammation
  - ↓ wound repair
  - ↓ new blood vessels.
Vascular testing

- Bedside Ankle brachial index (ABI)
  - Normal 0.8-1.3
- Skin perfusion pressure (normal >35 mmHg)
- Transcutaneous Oximetry (TCOM).
- Segmental arterial studies (lab test).
- Angiogram (referral).

Vikramjit Chhokar, MD (speaker today)
Definition: TCOM

- Evaluates “dose” of O2 at tissue-at-risk.
Transcutaneous Oximetry (TcPO2) adds to vascular workup

- Room air = 21% (760 mm Hg) = 157 mm O2
- TcPO2 > 40 mm Hg normal: GOOD PX
- TcPO2 < 20 mm Hg ischemic: BAD PX
- Confirmed by 100% O2 challenge

Understand wounds:
Types of Chronic Wounds

- Post-surgical
- Pressure
- Venous
- Neuropathic
- Ischemic (Arterial)
Post Surgical Wounds

- **Types**
  - Dehiscence
  - I&D (e.g., abscess)
  - Post surgical debridement.

- **Treatment**
  - Get to granulation.
  - Topical (bulky, moist dressings)
  - Negative pressure therapy.
Negative Pressure Therapy

- **Indications:**
  - Early healing phase (80% red; minimal yellow)
  - Measurable depth

- **Benefits:**
  - Rapid granulation and depth reduction of post surgical and pressure ulcers.
  - Reduced dressings costs, nursing visits

60 year old with perforated sigmoid diverticulum

- Morbid Obesity, HTN
- 7/7/09: Left hemicolecctomy with colostomy
- 7/31: Presented to Fort Healthcare Wound Edema Center
- 8/6: Wound saucerized and debrided.
Post op week six: 14cm x 6.5cm x 9 cm: VAC therapy at Black Granufoam @ 125 cont.
Post op week 8
Post op week 15: 99% closed.
Negative Pressure Therapy

- **Contraindications (FDA warning):**
  - Untreated osteomyelitis.
  - Untreated deep soft tissue infection.
  - Exposed artery
  - Neoplasm.

- There have been 7 deaths and 50 hospitalizations using NPT in 2009.

- With these caveats NPT is “de facto” standard of care.
Pressure Ulcers
Pressure ulcer risk: Braden scale

- Moisture (Incontinence)
- Activity
- Mobility
- Friction and shear (contractures)
- Nutrition
- Impaired sensation (lethargy)

What stage????
“Deep Soft Tissue Injury Under Intact Skin”
DTI: Definition and Interpretation:

- This is deep soft tissue injury under intact skin.
- “Deep soft tissue injury under intact skin” is a new designation, that might be termed “tissue infarction”.

Evolution of DTI:

- Evolves according to forensic principles, consistent with post-mortem decomposition of the human body.
- 2 days: Livido (redness which could be confused with a stage I pressure ulcer).
- 1 week: Purple
- 2 weeks: Black or yellow eschar.
- 4 weeks: Necrosis

Evolution of DTI (continued)

- Once DTI becomes visible, it is already too late!
- Already “unstagable” which may evolve into stage IV.
- “Aggressive prevention”.
84 year old female with DTI

- Fell at home ➔ right femur fracture.
- Found on floor 2/6.
- ORIF at Madison Hospital
- Evaluated at Johnson Creek 2/26: Copious foul smelling drainage.
DTI c/b Osteomyelitis.

- 3/15: MRI: Positive for “superficial osteomyelitis”.
- Etrapenem IV via PICC for six weeks.
- On NPT since D/C from Madison Hospital.
- NPT 125 mm Hg “black foam”.
Lower Extremity Edema
LE Edema: Lymphedema

- Stage I: Pitting.
- Stage II: Non-pitting, fibrosis.
- Stage III: Elephantiasis.
Other end of the spectrum: Venous Stasis Disease

- Venous stasis disease.
- Disease of veins.
- Venule damage, inflammation, hypoxia, sequestration of growth factors.
- Treat edema = heal wound.
Venous Stasis Ulcers: Epidemiology:

- 400,000 to 600,000 venous stasis ulcers/year US
- Age dependence
  - Overall prevalence 1%
  - >65 years prevalence 3-5%
- Females > Males
Presentation

- Between foot and knee
  - Medial malleolus
  - Lateral malleolus
- Hyperpigmentation
- Red base
- Irregular borders
- Lipodermosclerosis
- Pitting edema
Venous Ulcers: Pathophysiology

- Venous stasis
- Venous return
  - Incompetence of valves
  - Iatrogenic
  - Chronic deep venous thrombosis
  - Vein removal
Venous Ulcers: Treatment

- **Standard of care: Compression**
  - Debridement
- Drainage management
- Vascular workup
- Pain management
- Education
- Supply logistics

What can a leg ulcer be?

- Venous stasis (85%)
- Arterial disease
- Edema (SCI, CVA)
- Lymphedema
- Sickle Cell Anemia
- Neoplastic:
  - Basal cell CA
  - Cutaneous Lymphoma
- Infectious:
  - Cutaneous TB (olden days)
  - Cutaneous Anthrax
- Autoimmune:
  - Vasculitis,
  - Pyoderma gangrenosum

Methods to apply leg compression

- All **TOE TO KNEE**

- More aggressive compression necessary for healing (>40 mm Hg)
  - Long stretch (continuous pressure)
  - Short stretch, no stretch (transient pressure).

- Less aggressive to maintain healing (20-30 mm Hg)
  - Medical grade stockings (e.g., Jobst)
Three layer elastic compression

- Wound dressing
- Under layer gauze toe to knee
- Elastic (short stretch, long stretch, both) compression toe to knee
Elastic Compression – 3-layer
Multi-layer compression wrap
Multi-layer compression “Profore”
Unna “boot”

- How applied (figure of 8; strips)
- Watch excessive drainage!!
Long duration venous stasis wounds: Patient DB

- DB, 66 year old female
- Varicose veins, otherwise healthy (no diabetes)
- 1 year history of leg ulcers, left one year.
- Works on feet many years.
- Good arterial flow (ABI 1.06 bilaterally)
- Frequency of dressing changes decreased, compression increased, drainage gradually decreased:
- Returned to work after few weeks.
- Local infection noted five times; Predominantly Staph Aureus.
DB: Healed!
DB: Wound healing course
Prevention; long term maintenance

20-30 mm Hg compression stockings.
Neuropathic Ulcer
Neuropathic ulcers

- Polyneuropathy (usually from diabetes)
- Etiology
  - **Diabetes**
  - **EtOH**
  - Congenital (e.g., HSMN type I)
- Insensitivity to the 5.07 monofilament
- Foot deformities
- Develop ulcers at weight bearing bony prominences
- Brent Yaeggi DPM (speaker today).
Figure 7:
Neuropathic ulcers

- Presentation
- Workup - MRI, TcPO2, PVR
- Treatment
  - Debridement
  - Drainage management
  - Vascular workup
- Standard of care: Off loading

More important what you take off, than put on
Myth: All Off-loading is created equal

- Wound healing at 12 weeks:
  - Half shoe 58.3%
  - Removable “walker” 65%
  - Total contact cast 89.5% (p<.05)

“Diabetic Healer Walker”
AKA
DH Walker
Patient: JA

- 90 year old lady
- Ulcer bottom of foot >4 years duration.
- Diabetes, Stroke
- Numb foot: “walks on wound”
- Foot deformity due to diabetes
- Serious infection 1/2009 → septic shock.
- On hospice because of wound.
Initial presentation: Celulitis
Prevention; long term maintenance of healing: Orthopedic oxford shoes
Arterial Ulcers
Arterial or Ischemic ulcers

- Cardiac risk factors
  - HTN
  - DM
  - Chloresterol
  - Family Hx
  - Smoking
- Bony prominences, lateral foot margins
Figure 8:
Ischemic ulcers

- **Presentation** – wounds expand and deepen!
- **Workup** – MRI, TcPO2, PVR, MRA, Arteriogram
- **Treatment**
  - **Standard of care: Revascularization**
  - Off loading (similar to neuropathic)
  - Drainage management
  - Debridement – be careful!
Adjunctive therapies

- **Hyperbaric Oxygen**

- **Electrotherapy**

- **Timed compression boot (Dillon boot).**
Healing of Arterial Ulcers (yellow bars)

![Graph showing healing of arterial ulcers over time.](image)

- **Wound Area (%):** Normalized to 100% at week 0.
- **Time (Weeks):** Range from -4 to 52.
- **Bars Represent:**
  - HVPC+Std-of-care
  - Standard-of-care

*Note: The graph illustrates the comparison of wound area healing between HVPC+Std-of-care and Standard-of-care over time.*
Micro-circulation Improved in HVPC Group

- **TcPO\textsubscript{2} (mm Hg)**

<table>
<thead>
<tr>
<th>Condition</th>
<th>TcPO\textsubscript{2} (maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVPC+std-of-care</td>
<td><em>(max)</em></td>
</tr>
<tr>
<td>Standard-of-care</td>
<td></td>
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</tbody>
</table>

* indicates a significant difference between groups.
Complex Diabetic Ulcer
Hyperbaric Oxygen
Clinical Review

Hyperbaric Oxygen Therapy for Wound Healing and Limb Salvage: A Systematic Review

Robert Goldman, MD

A systematic review evaluating published clinical evidence of the efficacy of hyperbaric oxygen therapy (HBOT) for wound healing and limb salvage. PubMed/MEDLINE database for keyword 'Hyperbaric Oxygenation' with search limits: human studies, 1978-2008. Results compiled by Redonde AGD with 1 of the 3 following search methods: (i) search a local library (16 publications), (ii) compress the search results in a secondary database (50), or (iii) search a primary database (1). The search evaluated 620 citations, of which 84 reported original observational studies and randomized controlled trials (RCT) on HBOT and healing outcomes. All citations with 3 subjects were searched for full text review (44 articles) and evaluated according to GRADE criteria for high, medium, low, or very low level of evidence. A Cochran's test identified a additional study with a low level of evidence. This systematic review discusses and elaborates every article of high or moderate level of evidence. For patients with diabetic foot ulcers (DFU) complicated by surgical infection, HBOT reduces chance of amputation (OR 0.242, 95% CI 0.137-0.428, 7 studies) and improves chance of healing (OR 9.992, 95% CI 3.972-25.31, 10 studies). Positive efficacy corresponds to HBOT-induced hyperemia, elevation of an risk tissue (7 studies) as measured by transcutaneous oxygenometry. HBOT is associated with resolution of about 88% of cases of refractory lower extremity osteomyelitis, but an RCT is lacking to clarify extent of effect. There is a high level of evidence that HBOT reduces risk of amputation in the DFU population by promoting partial and full healing of problem wound. There is moderate level of evidence that HBOT promotes healing of arterial ulcers, calciphylaxis and refractory vascular ulcers, as well as refractory osteomyelitis. There is low to moderate level of evidence that HBOT promotes successful "take" of compromised flaps and grafts.

INTRODUCTION

Wound care practice is traditionally an important role for physicians. The practice continues today in the treatment of patients with traumatic and wound care. Physicians can also participate in the care of potential amputees with "at risk" foot and provide wound healing techniques (HBOT) for complex wounds, as an option for some patients. Outpatient wound clinics (correctly number 2000) compared with almost 100 15 years ago and a sizable number of these are for-profit wound management organizations. Such outpatient settings offer new opportunities to physicians to focus on wound care. In addition, teaching and research opportunities for such wound care specialists have greatly expanded. A notable example is the Physical Medicine and Rehabilitation Department at East Carolina University, which launched the first academic-based specialist wound center in 2007.

Because many of these wound care centers offer hyperbaric oxygen therapy (HBOT), an increasing number of physical medicine and rehabilitation physicians are becoming certified in or practice HBOT. HBOT under wound care is an American Board of Medical Specialties recognized specialty, offered by the Board of Preventive Medicine. Physicians in HBOT practice, with 2 years of postgraduate experience, may sit for the Undersea and Hyperbaric Medicine Board Examination until 2010. After 2010, an HBOT fellowship will be required.

HBOT is defined as compression of the whole body with at least 1.4 atmospheres absolute pressure (ATA) of pure oxygen. Since the 19th century, HBOT has been
Odds ratio: Amputation reduction DFU

Meta-analysis

Favored HBOT
Improved healing with HBOT: Randomized controlled trial
Case Study: RW

- 66 year old male with Rheumatoid Arthritis
  - No diabetes
  - PAD right leg and foot
  - OM of the big toe by plain film
  - Hallux amp 9/21/10.
  - Large plantar flap down to the proximal phalanx of the toe.
Patient RW

- Seen by a general surgeon in past six weeks (Sept 2010): “no reconstructable arterial disease”.
  - No diabetes.
  - ABI right = 0.94
  - TCOM: forefoot 2, 23 and 29 mm Hg, increased by 20-40 mm Hg with 100% O2 by FM.
RW: Photos
RW Healing Rate

HBOT
Conclusion: Chronic wound care in five easy steps:

<table>
<thead>
<tr>
<th>Ulcer Diagnosis</th>
<th>Standard of care</th>
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<tbody>
<tr>
<td>Post-surgical</td>
<td>Negative pressure</td>
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<tr>
<td>Pressure</td>
<td>Negative pressure, nutrition, offloading</td>
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<tr>
<td>Venous</td>
<td>Compression</td>
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<tr>
<td>Neuropathic</td>
<td>Off-loading</td>
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<tr>
<td>Arterial</td>
<td>Revascularization</td>
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</table>
Pressure ulcers: Standard of Care

- Measurement
- Off-loading
  - Support surface
  - Turn and Position
- Optimal nutrition
- Treatment
  - Debridement
  - Moisture balance
  - Surgical referral (Stage III/IV)

Overall approach (continued)

- Venous stasis ulcers:
  - Compression
  - TOE TO KNEE DRESSINGS
  - Staged debridements
  - Moist wound environment
Overall approach (continued)

- Neuropathic
  - Wound bed preparation
  - **Off loading**
  - Sharp debridement
  - Total contact casting
Overall approach

- Arterial/Ischemic:
  - Standard of care: Revascularization
  - Non-invasive arterial testing.
  - Also use compression or off-loading (standard of care for neuropathic or venous ulcers).
  - Hyperbaric Oxygen (especially for diabetic foot ulcers).
"Treat the whole patient, not the hole in the patient"
THANK YOU FOR YOUR ATTENTION!