OBJECTIVES

• Identify factors which contribute to non-healing in the DFU patient.

• Learn who to call for help and when to make that call.
DIABETES IS INCREASING

- 23.6 million people in the U.S. have diabetes
- \( \frac{1}{4} \) don’t know it
- 15% will develop Diabetic Foot Ulcers (DFU)
85% of Amputations can be prevented with:

- Early detections
- Proper treatment
RECOMMENDATIONS FROM EVIDENCE

CONSENSUS RECOMMENDATIONS ON ADVANCING THE STANDARD OF CARE FOR TREATING NEUROPATHIC FOOT ULCERS IN PATIENTS WITH DIABETES

APRIL 2010 OSTOMY AND WOUND MANAGEMENT
TREATMENT OF DFU’s

- DEFINE
- DISCUSS
- DEBRIDE (VESSELS AND BED)
- DEBUG
- DE-LOAD
- DECIDE
DEFINE

- History
  - Diabetes duration and control
  - Associated co-morbidities, other illness
  - Previous wound healing history
DEFINE

• SKIN AND ULCER EXAM
  o Skin
  o Sensation
  o Deformity
  o Ulcer: Size, Location, Base, Wound edge, Tunnel, Necrosis
DEFINE DEFORMITY

- Foot deformity
- Calluses
Neuropathy

- 58% of patients with longstanding disease
- 82% of patients with DFU have neuropathy
WOUND CLASSIFICATION

- Wagner Grade: exposed structure, infection or necrosis
- University of Texas: depth, infection and/or ischemia
## Wagner Classification System

<table>
<thead>
<tr>
<th>Grade</th>
<th>Lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No open lesions: may have deformity or cellulitis</td>
</tr>
<tr>
<td>1</td>
<td>Superficial ulcer</td>
</tr>
<tr>
<td>2</td>
<td>Deep ulcer to tendon or joint capsule</td>
</tr>
<tr>
<td>3</td>
<td>Deep ulcer with abscess, osteomyelitis or joint sepsis</td>
</tr>
<tr>
<td>4</td>
<td>Local gangrene - forefoot or heel</td>
</tr>
<tr>
<td>5</td>
<td>Gangrene of entire foot</td>
</tr>
</tbody>
</table>
## University of Texas Diabetic Wound Classification System

<table>
<thead>
<tr>
<th>Presence of infection or ischemia</th>
<th>Wound Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>A Pre- or postulcerative lesion with complete epithelialization</td>
<td>Superficial wound. No involvement of tendon, bone or capsule.</td>
</tr>
<tr>
<td>B Pre- or postulcerative lesion with complete epithelialization and infection.</td>
<td>Superficial wound. No involvement of tendon, bone or capsule. Presence of infection.</td>
</tr>
<tr>
<td>C Pre- or postulcerative lesion with complete epithelialization and ischemia.</td>
<td>Superficial wound. No involvement of tendon, bone or capsule. Presence of ischemia.</td>
</tr>
<tr>
<td>D Pre- or postulcerative lesion with complete epithelialization, infection and ischemia.</td>
<td>Superficial wound. No involvement of tendon, bone or capsule. Presence of infection and ischemia.</td>
</tr>
</tbody>
</table>
DEFINE

• INFECTION
  o Drainage
  o Odor
  o Redness
  o Swelling
  o Probe Bone
  o If suspicious:
    o ESR, CRP (If both are normal, Osteomyelitis is unlikely)
  o Culture
IMAGING

• Plain films

• MRI or CT
A tiered approach is recommended:

1. Pulses, ABI, and/or TBI
2. Segmental pressure volume, SPP and TcPO2
3. Vascular consultation
TISSUE HYPOXIA

• TcPO2 < 40mmHg suggests impaired healing

• Risk of amputation is 161 times greater if TcPO2 < 20 rather than TcPO2 > 40

• Risk amputation is 55 time greater if ABI is < 0.45 rather than > 0.7
DEFINE

• LABS
  o CBC
  o HgA1c
  o Cholesterol, HDL, LDL
  o Homocysteine (Hcy)
HEMOGLOBIN A1C & WOUND HEALING

- **Methods:** A retrospective analysis of data gathered from multi-center, controlled, prospective, randomized FDA approved clinical trials is being conducted.
  - Analyzed several variables
  - Multilevel linear regression looking at HgbA1C on the % of wound healing at 12 weeks
  - The initial sample size was 458 subjects.

- **Results:** The final linear regression model (P<0.0001) found that higher HgbA1C levels were associated with lower percentages of wound healing (P=0.05), after adjusting for gender, body mass index, initial wound size, and method used to off-weight foot ulcers.

  For every 1% increase in HgbA1c there is a decrease of 3% in expected healing area

  - Hanft J, et al, South Miami Hospital & Harvard Medical School, APMA Scientific Meeting Abstract, 2009
HEMOGLOBIN A1C & WOUND HEALING

The odds of healing a diabetic foot ulcer decreased 14.3% for every 1% increase in hemoglobin A1c.

HgbA1c = 12

71% odds to heal
DEFINE

- LABS
  - CBC
  - HgA1c
  - Cholesterol, HDL, LDL
  - Homocysteine (Hcy)
Homocysteine (Hcy)

- Known risk factor for atherosclerotic vascular disease and is an inhibitor of nitric oxide (NO) bioactivity

- ↑ serum Hcy = ↓ wound NO bioactivity and impaired wound healing

- ↑ Hcy was observed in
  - 50% of patients with chronic wounds
  - 63% of patients with diabetic, neuropathic ulcers
FACTORS ELEVATING Hcy

• Environmental factors:
  Nutrition: Deficiencies of folate, B12, and B6
  Lifestyle factors: cigarette smoking, high alcohol and coffee

• Physiological conditions: genetic anomaly
  Aging and menopause
  Drugs: methotrexate, cyclosporine, metformin, anticonvulsant or hypolipidemic drugs may inhibition of vitamin B6 function.

• Disease states: Chronic renal failure, hypothyroidism, SLE, several cancers, and spinal cord injury
Increased Plasma Homocysteine

- Decreased NO Production
- Decreased Wound NO Bioactivity
- Inhibited Wound Angiogenesis, Granulation Tissue Formation, and Collagen Formation

- Homocysteine-Mediated Inhibited Fibrin-Fibronectin Binding
- Defective Wound Matrix Formation
- Abnormal Wound Granulation Tissue Formation

Impaired Wound Healing

TREATMENT OF HYPER- Hcy

• Combination therapy of L-methylfolate, pyridoxal 5'-phosphate, and methylcobalamin is recommended as an effective treatment for lowering elevated Hcy.

• L-methylfolate administration has proven superior to folic acid therapy.
  - 7 times more bioavailable than folic acid
  - Results in 3X’s lower serum Hcy
DEFINE

• NUTRITION
  o Nutrition Screen
  o Albumin, Pre-Albumin, Transferrin

• SMOKING
Nutrition Screen

Height, Weight, BMI
Unintentional change in weight
  >5# in 1 month or >10# in 6 months
  >10 pounds in past 6 months
Persistent or recurrent diarrhea
Alcohol > 3 drinks per day
Mouth, tooth or swallowing problems
Tube feedings or TPN
Limited access to food
  Missing 2 meals/day > 2 days/week
Morning fasting blood sugar
• Albumin has a half-life of approximately 20 days, meaning a patient may be malnourished before an actual drop in albumin occurs
## Laboratory Data

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Moderately Depleted</th>
<th>Severely Depleted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Albumin</strong></td>
<td>&gt;3.5 g/dl</td>
<td>2.8-3.5 g/dl</td>
<td>&lt;2.8 g/dl</td>
</tr>
<tr>
<td><strong>Transferrin</strong></td>
<td>&gt;200 mg/dl</td>
<td>160-200 mg/dl</td>
<td>&lt;160 mg/dl</td>
</tr>
<tr>
<td><strong>Prealbumin</strong></td>
<td>&gt;14 mg/dl</td>
<td>11-14 mg/dl</td>
<td>&lt;11 mg/dl</td>
</tr>
</tbody>
</table>
DEFINED DISEASE PROCESSES

- ULCER
- DEFORMITY
- INFECTION
- VASCULAR STATUS
- NUTRITIONAL STATE
- DIABETIC CONTROL
DEFINE & DISCUSS

• Initial definition to determine what issues contribute to the problem
• Discuss with appropriate specialists
### Define and Discuss

<table>
<thead>
<tr>
<th>Condition</th>
<th>Responsible Professional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tissue Hypoxia</td>
<td>Vascular surgeon</td>
</tr>
<tr>
<td>Deformity</td>
<td>Ortho/ Podiatry/ Pedorthotist</td>
</tr>
<tr>
<td>Infection</td>
<td>Infectious Disease</td>
</tr>
<tr>
<td>Nutrition</td>
<td>Endocrinologist/ Dietician</td>
</tr>
<tr>
<td>Category</td>
<td>Protein Intake</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Healthy Patients</td>
<td>RDA for protein is 0.8g/kg each day (.36 g/pound)</td>
</tr>
<tr>
<td>Patients with Wounds</td>
<td>1.2 to 1.5 g/kg of protein (.5 to .7 g/pound)</td>
</tr>
<tr>
<td>Critically Ill, Stressed or Burned</td>
<td>2.0 g/kg of protein (.9 g/pound)</td>
</tr>
</tbody>
</table>
ARTERIAL DISEASE

- **Treatment**
  - Bypass
  - Endarterectomy
  - Stent
  - Hyperbaric Oxygen
WOUND BED PREPARATION AND DRESSING

- Debridement
  - Sharp
  - Mechanical
  - Chemical
  - Autolytic
WOUND BED PREPARATION AND DRESSING

Wound bed preparation = Management

– to accelerate endogenous healing
– facilitate the effectiveness of other measures

Convert the molecular and cellular environment of a chronic wound to an acute healing wound.
Bacterial biofilm is a major barrier to wound healing

- Bacteria protected from topical agents
- Low oxygen in biofilm niches
- Impaired migration and proliferation of keratinocytes
- Bacteria protected from systemic antibiotics
- Host defenses unable to clear infection
TREATMENT OF WOUND INFECTION

Contamination → Wound cleansing
Colonization → Debridement
Critical Colonization → Topical Agents*
Cellulitis → Antibiotics
Sepsis → Aggressive Abx

* Systemic Antibiotics do not penetrate granulation tissue
COMMONLY USED DRESSINGS

- Wound care dressing orders for 202 patients receiving home health or HMO care
  - 42% Wet-to-Dry
  - 7.5% Enzymatic
  - 7% Dry Gauze

Cowan L, Stechmiller J,
Advances in Skin and Wound Care
Dec, 2009
WOUND DRESSINGS

WET TO DRY DRESSINGS ARE ONLY APPROPRIATE FOR:

- Debridement when >50% of wound bed is non-viable
- For short periods of time
WOUND DRESSINGS

WET TO DRY DRESSINGS ARE INAPPROPRIATE BECAUSE:

- Increased Pain
- Lack of Compliance
- Increased Risk of Infection
- Re-injury to Healthy Granulation
- Increased Costs
GENERAL WOUND DRESSINGS

Moist Wound Dressing

- Healing times decreased by 2-3 times compared to Wet to Dry dressings
- Promote granulation
- Increase epithelial cell migration
DRESSING CHOICES

TO DRY:
• Alginates
• Foams
• ABD’s
• Polymers

TO MOISTEN:
• Hydrogel
• Medihoney
• Ointments
DRESSING CHOICES

- **ANTIMICROBIAL**
  - Silver
  - Iodosorb
  - Medihoney

- **ACTIVE DRESSING**
  - Collagens
  - Regranex
  - Skin Substitutes
DE-LOAD

(Off- Load)

OFF LOADING DEVICES
<table>
<thead>
<tr>
<th>Percentage of Area Reduction @ 4 weeks</th>
<th>Complete Healing @ 12 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;53%</td>
<td>58%</td>
</tr>
<tr>
<td>&lt;53%</td>
<td>9%</td>
</tr>
</tbody>
</table>
Percentage of Area Reduction = 

\[ \frac{(A_1 - A_2)}{A_1} \times 100 \]

\[ A = \text{Length} \times \text{Width} \]
• 50% REDUCTION IN 4 WEEKS

Width: 2.5 cm
Length: 1.5 cm
Area: 2.95 cm²

Width: 1.8 cm
Length: 1.1 cm
Area: 1.47 cm²
• **Negative Pressure Wound Therapy**
FAILURE ➔ ADVANCED TX

Living Skin Substitutes
Hyperbaric Oxygen Therapy
Deformity can be mitigated with appropriate footwear.

Severe deformity may be corrected with surgery.
DFU’S ARE HARD TO HEAL

Even with adequate blood flow

• 24% of patients closed at 12 weeks
• 31% at 20 weeks

Using standardize protocols in a multi-center wound care network

• 68% healing rate at 20 weeks
LIMB SALVAGE TEAM

- Multiple problems contribute to critical wounds and potential amputation.

- Multiple doctors with expertise in their area working together to save a leg.