**It Takes A Community: Caring for Complications of the Diabetic Foot**

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**OBESITY AMONG US ADULTS, 2001-2010**

- There is a strong correlation between people who suffer from obesity and people who develop type 2 diabetes.
- Consequently, as the prevalence of obesity has increased, the incidence of type 2 diabetes has also increased. Actions (continued)

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**DIABETES: THE FASTEST GROWING DISEASE IN THE US**

- In 2000, the prevalence of diagnosed diabetes was 8% in half of all US States.
- By 2010, all states had a prevalence of at least 5% in 15 states it was >5%.
- Approximately 41.5 million people are diagnosed with diabetes each day.

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From 1980 to 2011 the number of Americans with diagnosed diabetes more than tripled.

An estimated 12.7% of Americans with diabetes develop a foot ulcer.

60% of all lower extremity amputations in the USA are among persons with diabetes.

It has been suggested that 85% of amputations can be avoided when an effective care plan is adopted.

DFU’s are complex, chronic wounds, which have a major long-term impact on morbidity, mortality and quality of patients’ lives.

THE ECONOMIC BURDEN OF DFUS

- Those who develop DFU's can be effectively treated in clinics and hospitals.
- A study of Medicare data demonstrated a cost of treating patients with DFU's.

DFUS OFTEN RESIST HEALING AND BECOME CHRONIC

The healing of neuropathic DFUs is a challenge. Despite implementation of good standards of care, these wounds do not heal.

Noting that non-healing wounds are often associated with worse outcomes, the National Pressure Ulcer Advisory Panel guidelines recommend early referral for specialized care.
**DFU OFTEN RESIST HEALING AND BECOME CHRONIC**

The healing of neuropathic DFUs is a challenge despite implementation of good standards of care treatment.*

*Ref 1, p 76

Dyssynergic or displaced soft tissue infection.

*Ref 2, p 10

**EARLY PREDICTOR OF NONRESPONDERS TO STANDARD CARE: DFU PERCENT AREA REDUCTION <53% FROM BASELINE AT 4 WEEKS**

- Analysis of a multicenter, prospective randomized control trial, 12 most trial patients randomized to receive either a Prograheal®-treated grade 370 patients with non-healing, chronic wounds who received standard wound care.
- eg, frequent debridement, adequate off-loading, and serial dressings.
- Objective was to assess the ability of the 4 week healing rates to predict complete healing over a 12-week period.

**SUCCESSFUL DIAGNOSIS & TREATMENT**

- Optimal diabetes control
- Effective local wound care
- Infection control
- Pressure relieving strategies
- Restoring pulsatile blood flow
- Multidisciplinary team approach

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*Ref 1, p 17
*Ref 2, p 12
*Ref 3, p 17
ETIOLOGY OF DFU’S

- Neuropathic
- Ischemic
- Neuroischemic

PERIPHERAL NEUROPATHY

- The loss of protective sensation experienced by patients with sensory neuropathy renders them vulnerable to physical, chemical and thermal trauma
- Motor neuropathy can cause foot deformities, which may result in abnormal pressure over bony prominences
- Autonomic neuropathy is typically associated with dry skin, which can result in fissures, cracking and callus.

Peripheral Arterial Disease

- Narrowed arteries reduce blood flow to limbs
- Diabetics are 2x more likely to have PAD than those without diabetes
- Up to 50% of diabetics also have PAD
- Key risk factor for lower extremity amputation
Neuroischemic
- Combination of neuropathic and ischemic
- More difficult to treat

<table>
<thead>
<tr>
<th>Feature</th>
<th>Neuroischemic</th>
<th>Neuropathic</th>
<th>Ischemic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesion</td>
<td>Nodule</td>
<td>Ulcer</td>
<td>Ulcer</td>
</tr>
<tr>
<td>Ulcer appearance</td>
<td>Callus present and often thick</td>
<td>Ulcer present</td>
<td>Ulcer present</td>
</tr>
<tr>
<td>Wound bed</td>
<td>Pink and granulating, surrounded by callus</td>
<td>Pale and sloughy with poor granulation</td>
<td>Poor granulation</td>
</tr>
<tr>
<td>Foot temperature and pulses</td>
<td>Warm with bounding pulses</td>
<td>Cool with absent pulses</td>
<td>Cool with absent pulses</td>
</tr>
<tr>
<td>Typical location</td>
<td>Weight-bearing areas of the foot, such as the metatarsal heads, the heel, and over the dorsum of the clawed toes</td>
<td>Tips of toes, nail edges and between the toes and lateral borders of the foot</td>
<td>Margins of the foot and toes</td>
</tr>
</tbody>
</table>

ASSESSMENT OF THE DIABETIC FOOT ULCER
- Key skill for non-specialist practitioner is knowing when and how to refer
- History
- Medications
- Comorbidities
- Diabetes status
- History of wound
- Previous wounds or amputations
- Symptoms suggestive of neuropathy of PAD
EXAMINATION OF THE ULCER

- Neuropathic, ischemic or neuroischemic
- If ischemic, is there critical limb ischemia
- Musculoskeletal deformities
- Size/depth/location of wound
- Color/status of wound bed, exposed bone, necrosis or gangrene
- Infection, systemic signs of infection
- Odor, pain, exudate (color and consistency)
- Status of wound edge (callus, maceration, erythema, undermining)

TESTING FOR LOSS OF SENSATION

10g Monofilament
- Most frequently used
- Apply filament to various sites along plantar aspect of the foot- a positive result is the inability to feel the monofilament when it is pressed against the foot

Tuning Fork
- Neuropathy is demonstrated by inability to sense vibration from a standard tuning fork
Testing for vascular status

- Palpation of peripheral pulses
- Refer to specialist for full vascular if PAD is suspected
- Doppler ultrasound, ABI, Doppler waveform
- Toe pressures
- Transcutaneous Oxygen Monitoring

Common terms explained

- **Critical limb ischemia**: chronic manifestation of PAD where the arteries of the lower extremities are severely blocked. Results in ischemic pain in the feet or toes even at rest. Complications of poor circulation include skin ulcers or gangrene. If left untreated, it will result in amputation of the affected limb.
- **Acute limb ischemia**: sudden lack of blood flow to a limb and is due to either an embolism or thrombosis. Without surgical intervention, complete acute ischemia can lead to extensive tissue necrosis within six hours.

**IDENTIFYING INFECTION**

**Risk Factors**

- A positive probe-to-bone test
- DFU present for more than 30 days
- A history of recurrent DFU
- A traumatic foot wound
- The presence of PAD in the affected limb
- A previous lower extremity amputation
- Loss of protective sensation
- The presence of renal insufficiency
- A history of walking barefoot

**Clinical Diagnosis and Cultures**

- Cultures: preferably soft tissue (or bone if osteomyelitis is suspected) or aspirations of purulent secretions
- Superficial swabbing shown to be inaccurate

**TABLE 2: Classification and severity of diabetic foot infections**

<table>
<thead>
<tr>
<th>Clinical signs</th>
<th>Grade</th>
<th>Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound size &gt; 1 cm</td>
<td>Grade 1</td>
<td>Lesions on foot, toes, or heel</td>
</tr>
<tr>
<td>Wound size &gt; 2 cm</td>
<td>Grade 2</td>
<td>Lesions on foot, toes, or heel, plus signs of infection (fever, WBC &gt; 10,000)</td>
</tr>
<tr>
<td>Wound size &gt; 3 cm</td>
<td>Grade 3</td>
<td>Lesions on foot, toes, or heel, plus signs of infection (fever, WBC &gt; 10,000) plus pain</td>
</tr>
<tr>
<td>Wound size &gt; 5 cm</td>
<td>Grade 4</td>
<td>Lesions on foot, toes, or heel, plus signs of infection (fever, WBC &gt; 10,000) plus pain and signs of systemic illness</td>
</tr>
</tbody>
</table>

- Cultures should not be taken from clinically non-infected wounds as all ulcers will be contaminated; sampling cannot discriminate colonization from infection.
- Refer patients urgently to a wound centre, foot specialist or ER for urgent treatment if there is acute spreading infection, critical limb ischemia, wet gangrene or unexplained red, hot, edematous feet. These clinical signs and symptoms are potentially limb and life-threatening.
Where necrosis occurs on the distal part of the limb due to ischemia and in the absence of infection (dry gangrene), mummification of the toes and autamputation may occur. In most of these situations surgery is not recommended.

### Assessing Bone Involvement
- Osteomyelitis may frequently be present in patients with moderate to severe diabetic foot infection.
- Can be difficult to diagnose in early stages.
- Chronic, large, deep, and lie over a bony prominence are at high risk.
- Visual bone is suggestive of osteomyelitis.

### Inspect for Deformities
- High-arch foot.
- Clawed or hammer toes.
- Visible muscle wasting in the plantar arch.
- Gait changes (such as foot slapping on ground).
- Hallux valgus, hallux rigidus and fat pad depletion.
- Charcot foot.

### Areas at Risk for DFU
- Innovative approaches.
Classification of DFU's

<table>
<thead>
<tr>
<th>Classification</th>
<th>Stage</th>
<th>Causes</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>Superficial ulcer, no deep tissue damage</td>
<td>Insulin use, diabetes, and age-related disease</td>
<td>Reference 1</td>
</tr>
<tr>
<td>Stage II</td>
<td>Nondisaplasing ulcer, partial-thickness</td>
<td>Insulin use, diabetes, and age-related disease</td>
<td>Reference 2</td>
</tr>
<tr>
<td>Stage III</td>
<td>Full-thickness ulcer, bone exposure</td>
<td>Insulin use, diabetes, and age-related disease</td>
<td>Reference 3</td>
</tr>
</tbody>
</table>

Classification systems should be used consistently across the healthcare team and be recorded appropriately in the patient's records. However, it is the assessment of the wound that informs management.

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Essential Wound Management of DFU's

- Treat underlying disease processes
- Ensure adequate blood supply
- Local wound care, including infection
- Pressure offloading
- Diabetes education

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Treating the Underlying Disease Process

- Treating any severe ischemia is critical to wound healing
- Achieving optimal diabetic control. Tight glycemic control and managing risk factors such as high blood pressure, hypolipidemia, smoking and nutritional deficiencies
- Addressing any physical cause of trauma, improper footwear, presence of any foreign bodies

Adequate Blood Supply

- A patient with acute limb ischemia is a clinical emergency and may be at great risk if not managed in a timely and effective way
- Decreased perfusion or impaired circulation may be an indicator for revascularization in order to achieve and maintain healing and to avoid or delay a future amputation
Tissue Debridement

- Surgical/sharp debridement: The gold standard technique for tissue management in DFUs is regular, local, sharp debridement using a scalpel, scissors and/or forceps
  - Removes necrotic/sloughy tissue and callus
  - Reduces pressure
  - Allows full inspection of the underlying tissues
  - Helps drainage of secretions or pus
  - Helps optimize the effectiveness of topical preparations
  - Stimulates healing

Sharp debridement should be carried out by experienced practitioners
- Practitioners must be able to distinguish tissue types and understand anatomy to avoid damage to blood vessels, nerves and tendons
- Sharp debridement is an invasive procedure and can be quite radical
- Vascular status must always be determined prior to sharp debridement
- Patients needing revascularization should not undergo extensive sharp debridement because of the risk of trauma to compromised tissues
- Not debriding a wound, not referring a patient to specialist staff for debridement, or choosing the wrong method of debridement, can cause rapid deterioration with potentially devastating consequences.

Neuropathic ulcer pre- (top) and post- (bottom) debridement
**Neuroischemic ulcer**
pre- (top) and post- (bottom) debridement

**OPTIMIZING LOCAL WOUND CARE**

**Tissue Debridement**

- **Autolytic Debridement**
  - Natural process that uses a moist wound dressing to soften and remove devitalized tissue

- **Hydrosurgical Debridement**
  - Forces water or saline into a nozzle to create a high-energy cutting beam. This enables precise visualization and removal of devitalized tissues in the wound bed

- **Larval Debridement**
  - Larvae of the green bottle fly can achieve relatively rapid, atraumatic removal of moist, sloughy slough, and can ingest pathogenic organisms present in the wound

- **At initial presentation of infection, it is important to assess its severity and take cultures to guide therapy**

- **Optimal specimens for culture should be taken after initial cleansing and debridement of necrotic material**

- **Patients with diabetes have immunological disturbances; therefore even bacteria regarded as skin commensals can cause severe tissue damage and should be regarded as pathogens when isolated from necrotic tissue specimens**

- **Ongoing negative bacteria, especially Gram-negative species, should be considered in the treatment plan if no improvement is noted after initial debridement and cleansing**

- **Blood cultures should be sent if fever and systemic toxicity are present**

- **Microbiologic evaluation**
  - **Optimal specimens for culture should be taken after initial cleansing and debridement of necrotic material**
  - **Patients with diabetes have immunological disturbances; therefore even bacteria regarded as skin commensals can cause severe tissue damage and should be regarded as pathogens when isolated from necrotic tissue specimens**
  - **Given negative bacteria, especially Gram-negative species, should be considered in the treatment plan if no improvement is noted after initial debridement and cleansing**
  - **Blood cultures should be sent if fever and systemic toxicity are present**

- **Clinical microbiologists/infectious diseases specialists have a crucial role; laboratory results should be used in combination with the clinical presentation and history to guide antibiotic selection**

- **Timely surgical intervention is crucial for deep abscesses, necrotic tissue and for some bone infections**
**BIOFILMS & CHRONIC PERSISTENT INFECTION**

- Biofilms are complex polymicrobial communities that develop on the surface of chronic wounds and delay healing.
- Microbes produce a matrix that is thick, slimy and very difficult for topical antimicrobials to penetrate.
- Treatment is aimed at disrupting the biofilm with repeated and vigorous wound cleansing and preventing reformation by using antimicrobial dressings.
- Appropriate wound bed preparation remains the gold standard for biofilm removal.

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**OPTIMAL DRESSING SELECTION**

**Remember…….**

- Dressings are not a substitute for sharp debridement, managing infection, offloading devices or diabetic control.
- Balanced- not too moist or too dry.
- Select dressings that best match appearance of the wound.

**Factors to consider…….**

- Location of the wound.
- Erosed (size/depth) of the wound.
- Amount and type of exudate.
- The predominant tissue type on the wound surface.
- Condition of the periwound skin.
- Compatibility with other therapies (e.g., contact casts).
- Wound bioburden and risk of infection.
- Assumptions of pain and tolerates at dressing changes.
- Quality of life and patient wellbeing.

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**OPTIMAL DRESSING SELECTION**

**Does the dressing…….**

- Stay intact and remain in place throughout wear time?
- Prevent leakage between dressing changes?
- Cause maceration/allergy or sensitivity?
- Reduce pain?
- Reduce odor?
- Retain fluid?
- Trap exudate components?

**Is the dressing…….**

- Comfortable, conformable, flexible and of a bulk/weight that can be accommodated in an offloading device/footwear?
- Suitable for leaving in place for the required duration?
- Easy to remove (does not traumatize the surrounding skin or wound bed)?
- Easy to apply?
- Cost effective?
- Likely to cause iatrogenic lesions?
Dry necrotic wound:
Select dressing to rehydrate and soften the eschar

Sloughy wound bed with areas of necrosis:
Select dressing to control moisture and promote debridement of devitalized tissue
Infected wound with evidence of swelling and Exudate:
Start empiric antibiotic therapy and take cultures
Consider selecting an antimicrobial dressing to reduce wound bio burden and manage exudate

A newly epithelializing DFU: It is important to protect new tissue growth

**DRESSING APPLICATION & WOUND MONITORING**

- Regular inspection of wounds is vital
- If infected or highly exudative, a healthcare professional should change the dressing and inspect the wound daily
- As the status of the wound changes the dressing may need to change
- Educate patients to look for signs of deterioration, such as increased pain, swelling, odor, purulence or septic symptoms
- Mark/monitor extent of any cellulitis

**WHEN APPLYING DRESSINGS...**

- Avoid bandaging over toes as this may cause a tourniquet effect (instead, layer gauze over the toes and secure with a bandage from the metatarsal heads to a suitable point on the foot)
- Use appropriate techniques (e.g., avoiding creases and being too bulky) and take care when dressing weight-bearing areas
- Avoid strong adhesive tape on fragile skin
- Avoid tight bandaging at the fifth toe and the fifth metatarsal head (trim the bandage back)
- Ensure wound dead space is eliminated (e.g., use a dressing that conforms to the contours of the wound bed)
- Remember that footwear needs to accommodate any dressing.
- Wounds should be cleansed at each dressing change and after debridement with a wound cleansing solution or saline.
- Cleansing can help remove devitalized tissues, re-balance the bio-burden and reduce biofilm to help prepare the wound bed for healing. It may also help to remove biofilm.
**MANAGING PAIN AT DRESSINGS...**

- Incorporate strategies to prevent trauma
- No unnecessary manipulation of wound
- When appropriate use low- or non-adherent dressings
- If a dressing becomes encrusted or difficult to remove, it is important to soak the dressing with saline to prevent trauma

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**PRESSURE OFFLOADING...**

**Disadvantages of TCC**

- Important to offload at-risk areas to redistribute pressures evenly
- Inadequate offloading leads to tissue damage
- Gold standard is the total contact cast (TCC)

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**RECOMMENDATIONS ON USE OF OFFLOADING IN TREATING UNCOMPROMICATED NEUROPATHIC FOOT ULCERS**

- Pressure relief should always be part of the treatment plan for an existing ulcer
- TCCs and non-removable walkers are the preferred interventions
- Forefoot offloading shoes or cast shoes may be used when above ankle devices are contraindicated
- Conventional or standard therapeutic footwear should not be used
- The hallmark of an appropriately offloaded wound is a noticeable lack of undermining at the wound’s edge at follow-up
Facts:
- Lower-extremity amputation often results in disability and a loss of independence; amputation is often more costly than limb salvage.
- Amputation should not be considered unless a detailed vascular assessment has been performed by vascular staff.
- 50% of patients who undergo an amputation will develop a further DFUs of the other limb within 18 months.
- Up to 50% of patients will develop critical limb ischemia in the other limb.
- 50-60% mortality 5 years post-amputation.

Amputation may be indicated in the following circumstances:
- Ischemic rest pain that cannot be managed by analgesia or revascularization.
- A life-threatening foot infection that cannot be managed by other measures.
- A non-healing ulcer that is accompanied by a higher burden of disease than would result from amputation. In some cases, for example, complications in a diabetic foot render it functionally useless and a well-performed amputation is a better alternative for the patient.

Steps to Avoid Amputation:
1. Improved foot care.
3. Management of peripheral vascular disease.
5. Medication management.
6. Smoking cessation.
7. Education on foot care.
TAKE AWAY

- DFUs are a major and increasing public health problem, affecting up to 25% of diabetic patients in their lifetime.
- The economic burden of DFUs is high, including healthcare costs, office visits, and hospitalizations.
- Even with good standard wound care, healing neuropathic ulcers in patients with diabetes continues to be a challenge.


TAKE AWAY

- A combination of conventional and adjuvant therapies for DFUs includes:
  - Conventional:
    - Off-loading and debridement
    - Wound dressing
    - Antimicrobial therapy
    - Intervention for PAD
  - Adjunct:
    - Laminade skin substitutes
    - Topical agents
    - Hyperbaric oxygen therapy (HBOT)
    - Negative pressure wound therapy (NPWT)


QUESTIONS?
REFERENCES


