Care of the Diabetic Foot

Dexter R. Joyner, DPT, CWS, CHT
Manager of Wound Care and Hyperbaric Medicine
Piedmont Athens Regional
No Financial Disclosures
What I'm about to tell you is gonna change your life forever. Are you really sure you want to know it?
Objectives

- The Foot
- Common Foot Problems for Diabetics
- Treatment and Prevention
THE FOOT

- 26 bones
- 33 joints
- 107 ligaments
- 31 nerves
Facts

- 8-10,000 steps/day
  - 1800 foot strikes/mile
- 3-4 x body weight on foot each step
  - 130 pound person
  - 500 pounds pressure
- 4-12 tons of impact per day

(Dr. Courtney Bordenkecher)
Ave person walk ~115,000 miles/lifetime

This adds up to walking more than four times around the earth

(Dr. Courtney Bordenkecher)
Foot Pain

- 3rd most common ailment behind cold and tooth decay
- Affects Women 3:1 men
- 75% of Americans will suffer in lifetime

(Dr. Courtney Bordenkecher)
66% Americans have foot pain regularly

Top self treatment
- Changing shoes or taking off

18% do nothing/live with pain

7% sought Dr.’s care

(Dr. Courtney Bordenkecher)
Feet: "mirror" of an individual's health.

- Many systemic diseases show themselves in the feet and legs
  - Diabetes
  - Rheumatoid Arthritis
  - Gout
  - Circulatory problems
Common Foot Problems

Athlete's Foot
Nail Fungus
Ingrown Toenails
Heel Pain
Corns and Calluses
Planters Warts
Bunion
Hallux Limitus
Hammertoes
Neuroma
Flat Feet
High Arches
Ankle Sprain/Fracture
Diabetic Feet

Ingrown Nails
Hammertoe
Painful Corns
Fungal Nails
Athlete's Foot
Warts
Painful Callous
Bunion
Orthotics
Heel Pain
Ankle Sprains
Pediatric Foot Problems
Gait Changes in Diabetes

- Individuals with diabetes:
  - Slower
  - Shorter step lengths
  - Longer stance phase
  - Wider base of support
  - Greater step time variability on irregular surfaces
  - Improper pressure distribution
  - Decreased ankle mobility, ankle moment, and ankle power during walking

Diabetes can be hard on the feet

Patients with Diabetes should take extra special care of their feet

Should have routine check ups with a professional
Glycosylation

“...glycosylation occurs when sugar molecules (glucose) floating around in our blood attach to protein molecules, diminishing their effectiveness and causing inflammation.”

- Dr. Michael Roizen

The process increases as we age.

These glucose-modified proteins are termed advanced glycosylation end products (AGE).
Affects of Glycosylation

- Decreased skin thickness
- Increase skin hardness
- Muscle atrophy and activation delay
- Decreased bone density
- Limited joint mobility
- Fat pad fibrotic atrophy and distal migration

(Diabetic foot biomechanics and gait dysfunction. Journal of Diabetes Science and Technology. 2010 July 1;4(4):833-45.)
Gait Changes in Diabetes

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What is the “Diabetic Foot”?  

Diabetic foot is a disease complex that can develop in the skin, muscles, or bones of the foot as a result of the nerve damage, poor circulation and/or infection that is associated with diabetes.

The Diabetic Foot may be defined as a syndrome in which neuropathy, angiopathy, and infection will lead to tissue breakdown resulting in morbidity and possible amputation (WHO 1995)

Any foot pathology that result from diabetes or it’s long – term results (Boulton 2002)

(Dr. Faiez Alhmoud, Surgery Dpt. Albashir Hospital, MOH)
Classical Diabetic Triad of Pathology

PVD

ULCER

Neuropathy
Infection

SENSORY NEUROPATHY

- Loss of pain sensation
- Unnoticed trauma (mechanical, thermal, chemical)
- Unchecked worsening of the lesion
- Formation of Callus
- Tissue damage & necrosis beneath the callus
- Dev of cavity filled with serous fluid
- Cavity erupts to the surface
- Resulting in ULCERation
COMMON LOCATIONS FOR CALLUS

LESSER METATARSAL HEADS

MEDIAL GREAT TOE

FIRST METATARSAL PHALANGE JOINT
Neuropathy

**MOTOR NEUROPATHY**

↓

Weakness & decreased contraction of foot muscles

↓

Atrophy /wasting of these muscles

↓

Foot deformity

↓

Abnormal gait

↓

Easy ULCERation
Foot deformities that predispose to ulceration include:

- Clawed toes
- Hammer toes
- Pes cavus
- Pes planus
- Charcot joint
- Talipes equinus (ankle joint rigidity)
- Hallux varus/valgus/rigidus
- Bunions (bony bump of hallux joint)
- Nail deformities
- Deformities from previous trauma/surgery
Charcot Neuropathic Osteoarthropathy (CN)

“...condition affecting the bones, joints, and soft tissues of the foot and ankle, characterized by inflammation in the earliest phase.”

Diabetic neuropathy most common etiology

“...localized inflammatory condition that may lead to varying degrees and patterns of bone destruction, subluxation, dislocation, and deformity.”

Rocker-bottom foot is hallmark deformity

May or may not have pain due to neuropathy

(Diabetes Care 2011 Sep; 34(9):2123-2129. Rogers, et al)
Neuropathy

**AUTONOMIC NEUROPATHY**

↓

Decreased sweat secretion

↓

Dry & brittle skin

↓

Easily cracks & fissures

↓

Infection occurs

↓

ULCERation
Gait Changes in Diabetes

- Slower
- Shorter step lengths
- Longer stance phase
- Wider base of support
- Greater step time variability on irregular surfaces
- Improper pressure distribution
- Decreased ankle mobility, ankle moment, and ankle power during walking

MACROangiopathy

Atherosclerosis of large arteries (i.e. PAD)
Increased peripheral resistance

Microangiopathy

Thickening of basement membranes of capillaries
Decreased capillary permeability

Decreased perfusion of foot structures
Decreased supply of immune components & Antibiotics

Poor wound healing GANGRENE
Blockages can occur in more than one vessel. Muscle below blockage begins to die.

Blood flows through vessel

Plaque reduces blood flow

Blood flow is blocked

Non-healing wounds due to restricted blood flow

Gangrene due to poor blood supply
Impaired defenses against infections:

- Decreased Leukocyte migration
- Decreased Phagocytosis
- Decreased Intracellular killing
- Decreased Chemotaxis
Evolution of a Diabetic Foot Infection:
December 5, 2013
Complex interplay of factors

Motor Neuropathy

Sensory Neuropathy

Autonomic Neuropathy

Vasculopathy

Dorsal Deformity

High Plantar Pressure

Loss of Protective Sensation

Dry Skin

Skin Breakdown

Ischemia

Infection

Amputation

Immune dysfunction

Ulceration and Amputation

- Five year mortality following first-time ulceration – 40%.
- Increases to 52-80% after major amputation.
- Proximal amputations associated with increased mortality.

SO...major amputation, especially proximal, does hasten death.

(Podiatry Today, April 2018, Vol 31, Issue 4, pp12-16.)
Data is not part of a randomized control trial (for obvious reasons).

Patients with higher mortality also had increased age, renal disease, peripheral arterial disease, and cardiovascular disease — patients’ comorbidities and health status influences outcomes.

Cause and effect become more difficult in these observational studies.
Ambulatory status may play a factor.  
1/3 patients will not walk again following a major amputation (higher in elderly and renal patients).  
Five-year mortality in ambulatory patients was 30% compared to 69% in non-ambulatory.

USE IT OR LOSE IT - - more Physical Therapy?!?
“You can’t list your iPhone as your primary-care physician.”
All patients with Diabetes should have yearly foot exam assessing:
- Peripheral neuropathy
- 10g Semmes-Weinstein monofilament test
Semmes-Weinstein monofilament test
Recommendations from WHO

All patients with Diabetes should have yearly foot exam assessing:

- Peripheral neuropathy
  - 10g Semmes-Weinstein monofilament test
  - At least one other sensory test – 128Hz tuning fork vibration, cotton wisp, pin prick

(https://www.who.int/diabetes/Diabetes-training-manual.pdf?ua=1)
All patients with Diabetes should have yearly foot exam assessing:

- **Peripheral neuropathy**
  - 10g Semmes-Weinstein monofilament test
  - At least one other sensory test – 128Hz tuning fork vibration, cotton wisp, pin prick

- **Peripheral arterial disease**
  - Post tibialis and dorsalis pedis pulses
  - Ankle/brachial index or toe-brachial index

(https://www.who.int/diabetes/Diabetes-training-manual.pdf?ua=1)
Ankle-brachial index

Traditional method: \[ \frac{\text{Higher ankle pressure}}{\text{Higher brachial pressure}} \]

Alternative method: \[ \frac{\text{Lower ankle pressure}}{\text{Higher brachial pressure}} \]

Traditional ABI: \[ \frac{130}{125} = 1.04 \]

Alternative ABI: \[ \frac{110}{125} = 0.88 \]

Brachial difference

BD: Higher brachial pressure – Lower brachial pressure

BD: \[ 125 - 120 = 5 \]
<table>
<thead>
<tr>
<th>ABI Value</th>
<th>Interpretation</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 1.4</td>
<td>Calcification / Vessel Hardening</td>
<td>Refer to vascular specialist</td>
</tr>
<tr>
<td>1.0 - 1.4</td>
<td>Normal</td>
<td>None</td>
</tr>
<tr>
<td>0.9 - 1.0</td>
<td>Acceptable</td>
<td>None</td>
</tr>
<tr>
<td>0.8 - 0.9</td>
<td>Some Arterial Disease</td>
<td>Treat risk factors</td>
</tr>
<tr>
<td>0.5 - 0.8</td>
<td>Moderate Arterial Disease</td>
<td>Refer to vascular specialist</td>
</tr>
<tr>
<td>Less then 0.5</td>
<td>Severe Arterial Disease</td>
<td>Refer to vascular specialist</td>
</tr>
</tbody>
</table>
### Ankle-Brachial Index (ABI)

**Table 3: ABI Value-Based PAD Severity Grade**

<table>
<thead>
<tr>
<th>ABI Value</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1.30</td>
<td>Poorly compressible</td>
</tr>
<tr>
<td>0.91-1.30</td>
<td>Normal</td>
</tr>
<tr>
<td>0.70-0.90</td>
<td>Mild</td>
</tr>
<tr>
<td>0.40-0.69</td>
<td>Moderate</td>
</tr>
<tr>
<td>&lt;0.40</td>
<td>Severe</td>
</tr>
</tbody>
</table>

\[
\text{ABI} = \frac{\text{Ankle Systolic Pressure}}{\text{Arm Systolic Pressure}}
\]

*ABI, ankle-brachial index; PAD, peripheral artery disease
*Based on the American Diabetes Association guidelines*
Recommendations continued....

...yearly foot exam assessing:

- Presence of current or healed ulcer
- Previous amputation
- Presence of callus
- Presence of deformity: claw toes, hammer toes, bony prominences; limited joint mobility
- Presence of Charcot arthropathy: redness, warmth, swelling or deformity, particularly if skin is intact.
- Signs of infection or inflammation: at least two of redness, warmth, induration, tenderness, purulent secretion.
- Signs of gangrene.

(https://www.who.int/diabetes/Diabetes-training-manual.pdf?ua=1)
Patients should receive education on avoidance of foot complications.
Diabetic Foot Care

- Inspect feet daily
  - Check for blisters, split skin, swelling, redness

- Keep nails filed
  - If become ingrown seek Professional help immediately

- To avoid dry skin
  - After bathing apply lotion
  - Do not apply between toes
Diabetic Foot Care

- Wear cotton socks with as few seams as possible.
- Wear supportive shoes that have a wide toe box.
- Wear shoes and socks at all times.
- Check shoes for objects before putting on
DO’S

- Be aware of foot conditions
- Alert care providers immediately if a problem is noted
- Inspect feet after removing shoes
- Wear white socks if at risk for wounds
- Daily foot hygiene and lubrication
- Regular toenail care
- Be fitted for proper footwear
- Regularly check shoes/orthotics for wear
- Select appropriate activities
- Optimize body weight/body mass index

DON’T’S

- Walk barefoot
- Use dry heat on the feet
- Soak feet in hot water
- Use chemicals or sharp objects to remove calluses
- Trim ingrown, embedded toenail edges
- Use nail polish
- Wear new shoes without frequent checks
- Wear socks with constricting bands
- Wear inappropriate shoes
- Smoke tobacco
Foot Management (WHO)

- Patients should receive education on avoidance of foot complications.
- Pre-ulcerative conditions treated by a trained professional: removal of callus, protecting/draining blisters, ingrown and thickened nails, antifungal treatment.
- Patients with gross deformities and/or absent pulses should be referred.
- Risk stratification for assessment.

(https://www.who.int/diabetes/Diabetes-training-manual.pdf?ua=1)
<table>
<thead>
<tr>
<th>Risk level</th>
<th>Low risk</th>
<th>Moderate risk</th>
<th>High risk</th>
<th>Active foot problem</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Features</strong></td>
<td>No risk factor except callus alone</td>
<td>Any of: • deformity • neuropathy • non-critical limb ischaemia</td>
<td>Any of: • previous ulcer • previous amputation • neuropathy with non-critical limb ischaemia • neuropathy with callus and/or deformity • non-critical limb ischaemia with callus and/or deformity</td>
<td>Any of: • Ulcer • Spreading infection • Critical limb ischaemia • Gangrene • Suspicion of acute Charcot arthropathy • Unexplained red swollen foot</td>
</tr>
<tr>
<td><strong>Action</strong></td>
<td>Assess Annually</td>
<td>Assess every 3-6 months</td>
<td>Assess every 1-3 months</td>
<td>Urgent referral</td>
</tr>
</tbody>
</table>
Diabetic Foot Examination

- D  deformity
- I  infection
- A  atrophic nails
- B  breakdown of skin
- E  edema
- T  temperature
- I  ischemia
- C  callus
- S  skin color

(Dr. Faiez Alhmoud, Surgery Dpt. Albashir Hospital, MOH)
## Risk Classification and Referral/Follow-Up

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Definition</th>
<th>Treatment Recommendations</th>
<th>Suggested Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No LOPS, No PAD</td>
<td>Provide patient education *</td>
<td>Annually, by (generalist and/or specialist)</td>
</tr>
<tr>
<td>1</td>
<td>LOPS = deformity</td>
<td>Consider prescriptive or accommodative footwear. Consider prophylactic surgery if deformity is not able to be safely accommodated in shoes. Continue patient education.</td>
<td>Every 3-6 months (by specialist)</td>
</tr>
<tr>
<td>2</td>
<td>PAD = LOPS</td>
<td>Consider prescriptive or accommodative footwear. Consider vascular consultation for continued follow-up.</td>
<td>Every 2-3 months (by specialist)</td>
</tr>
<tr>
<td>3</td>
<td>History of ulcer or amputation</td>
<td>Same as category 1. Consider vascular consultation for continued follow-up if PAD present.</td>
<td>Every 1-2 months (by specialist)</td>
</tr>
</tbody>
</table>

LOPS = loss of protective sensation  
PAD = peripheral arterial disease

*Patient Education

Instruct patients on:
- Proper footwear and not going barefooted—even indoors
- Daily foot inspection—look between the toes and on the sole of the foot
- Prompt reporting of any foot lesions, discoloration, or swelling

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## Semmes-Weinstein Monofilament (SWMF) Test

1. Place blood pressure cuff above pulse. Place Doppler probe over arterial pulse.
2. Place tip of monofilament on the arterial pulse. Ask the patient if they feel the touch.
3. Repeat on other foot.

## Calculation of Ankle-Brachial Index (ABI)

1. Anterior view, right lower limb, normal arterial anatomy.
2. ABI: Place blood pressure cuff above pulse. Place Doppler probe over arterial pulse.
   - Posterior tibial artery, ankle systolic pressure to dorsalis pedis artery
   - ABI calculation: (Dorsalis pedal systolic pressure/brachial systolic pressure) x 100

## Dermatologic Examination

- Dry skin
- Absence of hair
- Improved nail edges, long or sharp nails
- Intermittent incontinence
- Ulceration

## Screening for Neuropathy

- Semmes-Weinstein monofilament (14 a)
- Vibration perception threshold testing
- Vibration perception threshold >25 vva
- Tuning fork (120 Hz)
- Abnormal perception of vibration

## Vascular Examination

- Palpation of dorsalis pedis and posterior (tibial) pulses
- Ankle pulses
- Ankle-brachial index (ABI)
- ABI < 0.90, consistent with peripheral arterial disease

## Biomechanical Foot Assessment

- Plantarflexion dorsiflexion of ankles and great toes
- Diminished foot mobility
- Washing patient
- Decreased vascularity
- Imbalance, need for assistive devices
- Inspection of patient’s shoes
- Ill-fitting footwear
- Inspection for deformity
- Patients inability to see and reach his or her feet
- Corns, calluses, blisters
- Pleasure metatarsal heads
- Hemorrhoids, claw toes

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American Diabetes Association

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Providers need to examine for toe-box, wear and tear, etc.
Footwear

- Providers need to examine for toe-box, wear and tear, etc.
- For Medicare patients, only physicians that manage the diabetes can certify need for shoes or inserts.
- Shoes or inserts must be provided by podiatrist, orthotist, prosthetist, pedorthist, or another qualified individual.

(Medicare.gov/coverage/therapeutic-shoes-or-inserts)
Footwear – Coverage Guidelines

- One pair of custom-molded shoes and inserts
- OR -
- One pair of extra-depth shoes
- PLUS -
- 2 additional pairs of inserts each calendar year for custom-molded shoes
- 3 pairs of inserts each calendar year for extra-depth shoes
- Medicare will cover shoe modifications instead of inserts.

(Medicare.gov/coverage/therapeutic-shoes-or-inserts)
Do people wear their prescribed footwear?

- 50 patients provided footwear
- Received shoes for 2.7 years
- 22% wore the shoes all day
- 38% wore slippers at home
- ...some subjects saved their prescribed shoes for special occasions.

(Knowles, Boulton. Diabetes Care 1996)
Why??

- Unattractive
- Uncomfortable
- Do not fit well – “too big”
- Heavy
- Hot

Contributing Factor:

*Patients do not fear what they do not feel.*
Proper foot wear is important to protect against pressure points.

Highest pressures are usually present in the forefoot.

A ROM exercise program can significantly reduce peak plantar pressures in diabetic subjects.

(The effects of range of motion therapy on the plantar pressures of patients with diabetes mellitus. JAPMA;92(9), October 2002)
Ambulatory Aides

- Cane – increases base of support, balance, NO off-loading
- Crutches – PWB to NWB
- Walker – greater stability, PWB to NWB
- Wheel chair – NWB (except transfers or propelling with feet)
- Bed rest
Gold Standard of Off-loading?

Mean peak pressure for ulcers under metatarsal heads

(It’s not what you put on, but what you take off: Techniques for debriding and off-loading the diabetic foot wound, Clinical Infectious Diseases, 2004;39:S92-9.)
Total Contact Casting (TCC)

- TCC – effective in treating a majority of non-infected, non-ischemic plantar ulcers.
- Healing rates ranging 72% - 100% over 5-7 weeks.

(It's not what you put on, but what you take off: Techniques for debriding and off-loading the diabetic foot wound, Clinical Infectious Diseases, 2004;39:S92-9.)
Only 6% of DFU patients had “Gold Standard” TCC used
Cost of care with TCC was half that of those that did not have TCC
TCC was time consuming and poorly reimbursed
Inadequate reimbursement
Lack of familiarity with Clinical Practice Guidelines

(Why is it so hard to do the right thing in wound care. Wound Repair and Regeneration: 2010; 18:154-158)
52 year old diabetic male

- Wound for 18 months
- Had off-loading boot
- Previous skin substitute
- Worked on his feet on a loading dock

- TCC first applied 03/06/13
- Wound closed 04/05/13
- Cast 2 more weeks, then into diabetic shoes with molded inserts
“The pathway to amputation is littered with bandages and dressings which have deceived both the doctor and patient into thinking that by dressing an ulcer they were curing it”

- Dr. Faiez Alhmoud
Takeaways...

- Of all late complications of diabetes, foot problems are the most easily detectable and easily preventable.

- Strategies aimed at preventing foot ulcers are cost effective and cost saving.

- Relatively simple interventions can reduce ulcers and hopefully amputations.
Thank You!

“And in the end, it’s not the years in a life, it’s the life in the years.”

- Abraham Lincoln