Save That Foot

The Consequences of Diabetic Neuropathy and the At Risk Foot

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General Comments on Neuropathy

- In the chronic state is peripheral in presentation
- Can be unilateral but in diabetes mellitus often both feet are involved
- Glove and sock presentation
- Diabetics with long standing disease at greatest risk ( > 15 years )
- Poorly controlled blood sugar also a contributing factor
Etiology

- Diabetes is the most common disease state to manifest peripheral neuropathy
- 70% of diabetics have at least mild to moderate peripheral neuropathy
- Other conditions include spina bifida, Hansen’s disease, SLE, immuno-suppression such as cancer and AIDS, B vitamin deficiency, MS, alcoholism, PVD, CMT
Demographics

- Two forms are early onset type I insulin dependent, adult onset non-insulin dependent
- 16,000,000 diabetics in the US alone
- Over 700,000 are newly diagnosed each year
- US diabetes related medical costs exceed $1.4 million yearly
- 54,000 diabetes related lower extremity amputations per year, 60% of which are preventable with proper care
- 70% of amputations are preceded by foot ulceration
- 50% mortality rate within 3 – 5 years of amputation
Neuropathy Considerations

• General term literally describes an abnormal neurologic condition
• Can present more localized (nerve entrapment), regionally (sciatica), Generally (neuromuscular etiology), whereas diabetes is peripheral
• Bilateral “glove and sock” scenario
• Gradual onset (painless, decreased sensation, pins and needles, paresthesia type complaints), sudden onset associated with severe pain
• Three simultaneously presenting forms: autonomic, sensory and motor
• The microcellular mechanism of neuropathy is unclear, is related to small vessel arterial disease and an associated disruption of intra/extracellular metabolism and nutrient transfer
Clinical Findings in Neuropathy

- Pedal pulses may be palpable (small vessel disease)
- Skin trophic changes dry, scaly, fissures, thin, atrophic (autonomic)
- Structural abnormalities claw toes, drop foot, forms of equinus (motor)
- Insensate digits or portion of or all of one feet, both feet, ankle (paresthesia, pins, needles, prickling, burning (sensory))
- The rigid, insensate foot is at a greater risk of ulceration, than a flexible, sensate one
The Neuropathy Triad

- **Autonomic presentation** – skin trophic changes, increased injury susceptibility
- **Sensory presentation** – decreased touch and pain sensation, reduced ability to recognize trauma, increased risk of undetected ulceration with subsequent infection, often resulting in amputation
- **Motor presentation** – muscle atrophy, structural deformity, drop foot, increased shear forces, foot slap, drag forces, all of which contribute to increased risk of ulceration
In Office Testing for Neuropathy

- Very important, can be the first indication of neuropathy manifestation and/or the onset of diabetes mellitus
- Symes Weinstein 10 g (5.07) monofilament is 95% reliable in testing for sensory neuropathy
- Tuning fork tests for reduced vibratory sensation, often an early deficit in neuropathy (the feeling of a body part moving in space sensed at a joint, plays a role if subsequent Charcot changes)
- Bioesthesiometer also helpful in assessing reduced vibratory sensation
- Ankle jerk reflex is absent in advanced neuropathy
Symes Weinstein Filament Testing

- Test for LOPS, developed by Birke at the Hansen’s Disease Center
- Monofilament gives single point perception of touch, lack of which infers lack of protective sensation and sensory neuropathy
- Points of testing (toes, forefoot, arch, rearfoot)
- Test bilateral
- Patient should not be watching
- Do not test at points of callus or thickened skin
- Record keeping helps to track development of neuropathy
Symes-Weinstein Filament, Tuning Fork, Neurologic Hammer
Symes -Weinstein monofilament

Test points

Technique
The Beginnings of Catastrophe...

- Foot ulceration is the most severe manifestation of neuropathy
- There are many contributing factors including anatomy, biomechanics, weight with added shear and friction forces, decreased arterial vascular status especially small vessels, footwear, lack of patient knowledge regarding ulcer etiology, non-compliance
- 18 – 36 months opposite limb breakdown
- TO SAVE THAT FOOT, ULCER PREVENTION IS GOAL #ONE
Contributing Factors to Ulceration

Abnormal stress against the skin

- Low pressure over a long time ex. Improper shoe fit, toe box/toe interface
- Direct injury pressure ex. trauma, heat, chemicals
- Repetitive moderate pressure ex. metatarsal head prominence with plantar forefoot loading and callus
- Inappropriate shoe gear contributes to 70% of all foot ulcers
Further Ulceration Considerations

- Biomechanical/structural abnormality contributes to abnormal pressures (HAV, PGD metatarsals, drop foot)
- Forefoot fat pad distal migration seen with HDS creating increased metatarsal pressure
- Intrinsic muscle atrophy in motor neuropathy leading to claw toe, mallet toe with subsequent loading at distal tip of toes
- Reduced arterial vascular status especially small vessel disease impairs ability of skin to repair trauma
- Previous site of ulceration greatest area of re-ulceration due to scar tissue, lack of skin elasticity
- Lack of patient understanding/knowledge regarding ulcer etiology (barefoot ambulation, improper shoes, lack of daily self foot assessment, check inside of shoes, importance of tight blood sugar control, proper socks, skin texture management)
- Poor nutrition
- Body weight
Assessing Arterial Vascular Status

- Very important in ulcer development and healing prediction
- Pedal pulses may be palpable, in fact often bounding in Charcot process
- Integument exam findings are an indicator of vascular status (skin texture, temperature, DHG)
- Systems review may indicate claudication, rest pain, numbness
- Patient history, cardiac disease often accompanies PAD
- Body temperature thermography
- Doppler assessment
- Oximetry (Tcom)
Non Invasive Vascular Testing

Arterial Doppler

- Non palpable PT, DP mark location with hand held Doppler
- Strength of whooshing sound can provide a clue as to arterial flow
- Monophasic, biphasic, triphasic wave form on doppler tracing mirrors pulse strength
- ABI brachial artery /PT, DP ratio, an indicator of arterial inflow to forefoot (normal 1.0 mmHg, or above)
- TBI toe/brachial index an indicator of arterial inflow to digits (normal .75 mmHg or above)
- ABI less reliable in diabetics due to vessel incompressibility, arteriosclerosis
Non Invasive Vascular Testing

Tissue Oximetry

- T com ( Ptc O2 ), transcutaneous oxygen measurement
- Tertiary assessment of tissue perfusion ( primary - pedal pulses, secondary – ABI, TBI )
- More reliable than ABI in diabetic in predicting local arterial vascular status and healing
- Very important in wound care, indicates amount of O2 perfusion of tissues at the point of the lesion
- Can also be used if contemplating surgery on a diabetic
- Values > 40 normal healing, 30 – 40 impaired healing, < 30 healing not likely
- Also used to predict effectiveness of hyperbaric O2 therapy ( O2 challenge during oximetry, Tcom value >200, hyperbaric O2 therapy will be 88% effective )
Through the Podiatrist’s Eye

- We see the perils of neuropathy when associated with abnormal mechanical forces that lead to ulceration.
- Harris mat used to assess these forces.
- Current research at the Scholl College of Podiatric Medicine using remote sensors to monitor local pressures on the foot and joint movements in predicting and controlling neuropathy associated pathology.
- Evaluation of the wear patterns on shoe gear and insoles provide clues to abnormal forces, future problems.
- Local skin color and texture changes, combined with callus patterns, can be an ominous sign.
Reading Callus Patterns Creates A Map For Ulcer Prevention

- Local erythema is an early indicator of abnormal pressure, friction
- Pain is not a reliable indicator of problems
- Blistering or hyperkeratosis with subsequent ulceration may follow
- Plantar metatarsal head level is most common site for ulceration, $3^{rd}$ MTPJ #1 > digits > $1^{st}$ met head > $5^{th}$ met head > midfoot > heel
- Midfoot pressure less common unless associated with chronic Charcot rocker bottom deformity
Callus Pattern Etiologies...

- Metatarsal head level
  - plantar displaced metatarsals
  - abnormal metatarsal length pattern
  - cavus foot with plantar flexed 1st metatarsal
  - rearfoot or forefoot equinus
  - rigid plantarflexed 1st metatarsal plus equinus recipe for disaster

- Hallux Valgus
  - pinch callus, soft corn, medial pressure lesion

- Hammer digits
  - soft corn, dorsal pressure lesion

- Distal digital lesion
  - claw toe, mallet toe, sometimes associated with drop foot

- Heel lesion usually associated with debilitation
Comments About Charcot Arthropathy

A Periosteal neuropathy (non cutaneous), pedal pulses are palpable, often bounding

Acute Charcot clinical picture shows extreme local edema, erythema and local temperature increase, but no pain

- Contrary to osteomyelitis, no break in skin
- X-rays show destructive changes
- Triphasic bone scan, bone biopsy diagnostic
- 30% T-MTPJ, 30% MTPJ
- Healing times RF 12 mo., MF 9 mo., FF 6 mo.

Chronic Charcot clinical picture local edema, no local temperature increase, minimal erythema,

- Ulceration predisposition secondary to rocker bottom deformity and gait disturbance
Chronic Charcot foot with rocker bottom deformity
# Podiatric Intervention to Save That Foot

## Non Surgical
- Regular patient visits for podiatric care
- Patient and family education
- Appropriate shoes and break in period
- Diabetic socks
- Custom multiple density shoe inserts (remember the callous patterns)
- Pedorthic shoe modifications (remember the callous patterns)
- AFO

## Surgical
- Preventative intervention
- Definitive correction, usually amputation
- Ulcer management, covered in the Wound Care Update lecture
- Wound closure
Non Surgical Foot Ulcer Prevention

Thoughts on Patient Education

- 86% of amputations are preventable with patient education and proper shoe gear
- Etiology of 1 out of 5 foot ulcers is care giver related
- Non loading force exercise without increased risk of foot trauma (walking creates 150% of body weight force, running 300%)
- Daily patient self foot exam, with patient aware that the exam may be compromised by the disease process
- Evaluate the level of understanding of the patient of the disease process (may need to have family members present at consultation)
- Strive to have the patient proactive and motivated at prevention
Non Surgical Foot Ulcer Prevention

Purposes of Patient Education

- Improve foot problem knowledge
- Prevent escalation of a simple problem to a more severe one with early detection
- Reduce infection, amputation rates
- Have patient and family involved in the decision making process

Self Care Education

- Foot washing techniques (no soaking, non drying soap)
- Avoid dehydration
- No adhesives
- No barefoot ambulation
- Proper callus, toenail care
- Daily self foot exam
- Check inside of shoes before putting them on
Non Surgical Foot Ulcer Prevention

Appropriate Shoe Gear

- Off the shelf shoe or custom molded shoe
- Extra depth with deep round toe box, soft leather or Neoprene upper, crepe outer sole, lace up closure
- Diabetic socks (adequate stretch, cushioned heel and forefoot, no seam at toes, “toe socks” for excessive inter digital maceration)
- Shoe fit 1/2in. to ¾ space beyond longest toe
- Vamp pinch test for adequate width and upper material softness
- Pedorthic modifications include flared lateral heel and or sole as varus deformities are common in neuropathy, rocker sole, metatarsal bar, stiff shank especially important if FF or mid foot amputation, sole expansion
- Shoe break in period
- Shoe stretch if necessary
Primary choice
Considered when confronted with a mild deformity (structural deformity without hyperkeratosis or neuropathy)
Off the shelf extra depth shoes, custom made multi-density padded inserts

Secondary choice
Considered when confronted with moderate deformity (pre-ulcerative structural deformity with hyperkeratosis and neuropathy)
Off the shelf shoes, custom made multi-density padded orthoses, pedorthic shoe modifications

Tertiary choice
Consider when confronted with severe deformity (structural deformity with ulceration/amputation history and neuropathy)
Custom molded shoes, custom made multidensity padded and modified orthoses, pedorthic shoe modifications

Quaternary choice
Consider when confronted with most severe deformity, usually either after calcanectomy or Chopart amputation
Neuropathic walker, AFO with rigid extension and filler for mid and forefoot
The Role of Pedorthics in Foot Ulcer Prevention

**Diabetic orthoses**

- Full length, total contact, filling in spaces between the shoe and the foot
- Corrections are added to the bottom or in between layers of the orthosis
- Partial weight bearing casting
- Material synergy must relieve pressure and shear forces
- Plastizote, P-cell, Poron, puff, crepe are preferred materials
- Forefoot block for partial amputation, leave adequate space between block and stump,
- AFO, drop foot brace for severe instability, drop foot
The Role of Pedorthics in Foot Ulcer Prevention

Shoe modifications

- External
  - Rocker sole - Charcot, PGD mets, HDS
  - Metatarsal bar - PGD mets
  - Medial buttress – PPV + Charcot
  - Stiff shank -FF or MF amp
  - Lateral flare - varus deformity
  - Sole expansion - HAV
  - Negative heel- forefoot offload

- Internal
  - Sole excavation-Charcot
  - Stretching-HAV, HDS
When The Best Laid Plans...

The combination of the patient being unaware of the impending problem and ineffective unloading of pressure sets up the scenario......

Trauma > callus > inflammation > hematoma > ulceration > infection > ineffective wound care for multiple reasons > cellulitis, sepsis > gangrene > amputation
Surgical Management of Diabetic Complications

Foot ulceration management
- Incision and drainage if abscess
- Regular in office surgical debridement
- In hospital or surgery center ulcer excision with resection of tissue and bone
- These topics will be covered more extensively in the Wound Care lecture

Wound closure
- Primary wound closure if non-infected and good wound margins
- Skin graft (split thickness, full thickness, rotational, advancement)
Surgical Management of Foot Diabetic Complications

1. Preventative intervention with deformity correction
   - Early intervention can be cost effective
   - Onychoplasty for onychocryptosis, toenail dystrophy
   - Digital tendon release for claw toe, mallet toe
   - Metatarsal osteotomy for severe tylomata
   - Bunionectomy for hallux valgus

2. Definitive correction, usually amputation associated with gangrene, osteomyelitis
   - Determining amputation level
     - Point of demarcation or necrosis
     - Vascular assessment indicating satisfactory level of circulation for prediction of healing (arterial doppler, oximetry more preferrable)
   - Functional considerations are very important, always try to leave the most ambulatory stump, avoid transfer lesion
Types of Gangrene

**Dry**
- Tissue is dry, shriveled and black in color
- Line of demarcation between viable and dead tissue
- Non painful
- May be self-limiting

**Wet**
- Tissue reddish purple in color
- Moist and swollen, no line of demarcation
- Painful
- Tissue necrosis, often associated with infection
Levels of Amputation

- Hallux – interphalangeal joint or 1\textsuperscript{st} MTPJ disarticulation
- Lesser toe(s) – interphalangeal joint - level or lesser MTPJ disarticulation
- Ray amputation – distal metatarsal amputation
- Distal forefoot amputation – midshaft metatarsals 1-5
- Lisfranc – metatarsal/cunieform joint level
- Chopart – talus/cunieform joint level
Ist Ray Amputation

Lesser Toe IPJ Amputation
Functional Considerations and Amputation

- Hallux amputation interphalangeal joint level, leave a portion of proximal phalangeal base for sesamoid/FHB function
- Partial digital amputation for distal toe lesion, consider joining flexor and extensor tendons at interphalangeal joint capsule
- Single 2nd ray amputation preferred over 2\textsuperscript{nd} MTPJ disarticulation, less likely to cause HAV
- In all partial forefoot amputations consider subsequent equinus deformity
- Calcanectomy will need neuropathic walker or patellar tendon bearing orthosis
- Always try to leave as much residual stump as functionally acceptable, avoid transfer pressure
Case Study – The Slippery Slope

• Initial problem was osteomyelitis under 2ⁿᵈ MPJ resulting in 2ⁿᵈ ray amputation
  • Subsequently developed ulceration at tip of 3ʳᵈ, 4ᵗʰ toes which became gangrenous resulting in digital amputations,
  • Currently developed pre-ulcerative transfer lesion under 1ˢᵗ Mpj
• Also has concurrent Charcot arthropathy left midfoot being treated with a total contact cast
• Vascular status is excellent
• Significant neuropathy
• Poorly controlled blood sugars
In Conclusion, To Save That Foot....

- Neuropathy is a major contributor to diabetic foot complications, many cases of which are preventable.
- Multiple factors contribute to neuropathy.
- Treatment of the neuropathic foot must include patient education combined with pedorthic/podiatric applications.
- Judicious preventative surgical intervention can be helpful in preserving as much of the foot as possible.
- Functional/mechanical considerations must be taken into account when definitive surgery is indicated.
- Post surgical pedorthic/podiatric followup is critical to reduce further complications.
Thank you!

Acknowledgment to AOPP