Management of the DFU: It’s Like a Chess Game... But My King is HBOT!

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Disclosure

➢ NOTHING…
Diabetes: the fastest growing disease in the US

Diagnosed Diabetes Among Adults: Age-Adjusted Percentage

- In 2000, the prevalence of diagnosed diabetes was <6% in half of all US states.
- By 2010, all states had a prevalence of at least 6%; in 15 states it was >9%.
- Approximately 4110 people are diagnosed with diabetes each day.

Statistics on DM and DFU risk

National Institute of Diabetes Digestive & Kidney Diseases:

- As of September 2011 an estimated 16 million Americans are known to have diabetes, with many more at risk.
- Diabetic foot lesions are responsible for more hospitalizations than any other complication of diabetes:
  - 15% develop a foot ulcer
  - 12-24% of individuals with a foot ulcer require amputation.
  - Diabetes is the leading cause of nontraumatic lower extremity amputations in the United States.
  - Every year approximately 5% of diabetics develop foot ulcers
Major Complications of Diabetes Mellitus

- Neuropathy
- Microvascular disease
- Retinopathy, Nephropathy
- Protein glycosylation
- Macrovascular disease – CAD, CVD, PVD
- Immunopathy – susceptibility to infection
- Lower extremity amputation
Impact of Diabetes

- Dental disease
- Heart disease and stroke
- Hypertension
- Kidney disease
- Blindness and eye problems
- Nervous system disease
- Diabetic foot ulcers
- Amputation

Diabetes Related Major Lower Extremity Complications

- Ulceration
- Infection
- Lower extremity amputation
- Charcot foot (Osteoarthropathy)
Lower Extremity Amputation

- 15% lifetime occurrence of lower extremity ulceration
- 0.5 - 3.0% annual cumulative incidence of ulcer
- Ulceration leads to longer hospitalizations
- Foot ulcers are the precursor to amputation in 85% of lower extremity amputation in diabetic patients
  - 7-20% of ulcers subsequently require an amputation
- Diabetes is the leading cause of non-traumatic amputation and over 60% of all are diabetic and averaging 82,000 per year

Pathways to Amputation

Neuropathy

Trauma

Faulty Healing

Amputation

Ulceration

Diabetes Related Amputation

- Toe amputations are most common amputation (2.6/1000)
- Below the knee (1.6/1000), AKA (0.8/1000)
- 15-20 times higher in DM than non-DM
- Direct and indirect costs for diabetic foot disease can easily exceed $6 billion/year
- $20,000-60,000 per event, greater cost the higher the amputation

Diabetes Related Amputation

Among first-time amputees:

- 30-50% will require additional amputations within 1-3 years
- 50% will die within five years of an initial major amputation

It has been estimated that 50% to 75% of lower extremity amputations could be prevented…

by modifying risk factors and improving care among individuals with diabetes.

Etiology: Lower Extremity Ulcers

- Peripheral Arterial Disease (PAD)
- Peripheral Neuropathy (DPN)
- Foot Pathology/Deformities

These factors will commonly contribute to the development of Diabetic Foot Ulcers that can take several paths depending on the underlying factors.
Diabetic Foot Anatomy / Dynamics

- 26 bones
- 29 joints
- 42 muscles
- Average Person Walks 100,000 miles in their lifetime
DFU: The Four Key Factors

- Neuropathic
- Arterial
- Venous
- Deep Tissue Ischemia
DFU: Foot Pathology

Factors Related to DM Ulcers:

- Neuropathy
- PAD
- Callosities
- Structural Deformity
- Trophic Skin and Nail Changes
- Infections
  - Cellulitis (soft tissue)
  - Osteomyelitis (bone)
Foot Deformities

- Hammertoes
- Tight Achilles Tendon
- Charcot Foot
- Rocker Bottom
Hammertoes

- Motor neuropathy and imbalance of interosseus muscles
- Migration of metatarsal fat pads
- Deviation of metatarsal head
- Ulcerations on toes
Tight Achilles Tendon

➢ Glycosylation of collagen in Achilles tendon
➢ Limits joint mobility
➢ Deviation of metatarsal head
➢ Callus or ulceration
Biomechanics of Walking and Ulceration

Panel A shows the biomechanics of gait.

The normal mechanics of the foot and ankle result from the combined effects of muscle, tendon, ligament, and bone function.

Panel B shows the forces on the foot.

Friction and compressive forces are produced by the pushing down of the body weight and the pushing up of the ground reactive forces. Wasting of the intrinsic muscles of the foot results in an imbalance of the forces acting on the bony structures leading to:

- toe deformities
- prominent metatarsal heads
- equinus deformity, varus position of the hind foot proximal malalignment.

Panel C shows the consequences of callus formation

Inadequate distribution of the forces of weight bearing or the presence of foot deformities can lead to abnormal movement, which produces excessive stress and results in the breakdown of connective tissue and muscle.
Charcot Foot Deformity

- Neuro-arthropathy
- Increased perfusion softens bones
- Metatarsal heads and mid foot bone structures decompose
- Arch collapses
Diabetic Neuropathy
Diabetic Neuropathy

- Etiology unknown
  - Probably perineural damage from glycosylated compounds
  - Decreased blood supply to perineural tissues
- Increases amputation risk 1.7 fold
- 12 fold increase in amputation if deformity is present
- 36 fold increased amputation risk if history of prior ulceration
- Subclinical, Clinical
- Significant quality of life impact
Diabetic Neuropathy

➢ More than 60% of non-traumatic lower limb amputations in the USA occur among people with Diabetes
➢ Results in the Insensate Foot
➢ DM Neuropathy is the MOST IMPORTANT RISK FACTOR leading to ulceration
➢ DM Neuropathy is present in more than 80% of DM patients with foot ulcerations

Levin, 1995
Diabetic Tri-Neuropathy

➢ Sensory Neuropathy
  - LOPS “Loss of Protective Sensation”
  - Begins in feet can follow to hands

➢ Motor Neuropathy
  - Presents with Contracted digits
  - Intrinsic Muscular wasting, weakness, foot drop

➢ Autonomic Neuropathy
  - Decrease natural body oil production & sweat
  - Anhidrosis: decrease perspiration and excess drying
Manifestations

- Pain and/or paresthesias
- Numbness
- Autonomic neuropathy
  - dry/scaling skin
- Motor changes
- Edema formation
Detection of Neuropathy
Detection of Neuropathy

- Semmes-Weinstein monofilament
  - 10 gram (5.01) monofilament
  - Sensitive predictor of risk for ulceration and amputation
  - Less than 7 of 10 pressure sites patient has an absent protective threshold
Diabetes: Long-term Complications

Hyperglycemia

- Macrovacular Disease
  - Damage to medium and large blood vessels
    - Coronary Artery Disease
    - Cerebrovascular Disease
    - Peripheral vascular disease

- Microvascular Disease
  - Damage to small blood vessels
    - Retinopathy
    - Nephropathy
    - Neuropathy
Compromised Biology

Glycosylation of Collagen
“Stiff” joint (LJM) and soft tissue

Autonomic Neuropathy
Microneurovascular, Vasomotor, Endothelial Dysfunction
Anhidrosis

Immunopathy
Infection

Large Vessel Disease
Ischemia

Motor Neuropathy
“Intrinsic minus” Deformity
High Plantar Pressures
Imbalance of gait

Joint/Bone
Osteoarthropathy
Osteopenia
Hyperostosis

Sensory Neuropathy
Insensitivity
Increased physical stress

DeFronzo RA, Reasner C, The Diabetes Control and Complications Trial Study: Implications for the diabetic foot, J Foot Ankle Surg, 10=994;33:551-556.
Diabetes Mellitus

Trauma

Neuropathy
- Motor: Weakness, Atrophy, Deformity, Abnormal stress, High plantar pressure, Osteoarthropathy
- Sensory: Loss of Protective sensation, Anhidrosis, Dry skin, Fissures, Decreased Sympathetic tone (Altered blood flow regulation)
- Autonomic: Anhidrosis, Dry skin, Fissures, Decreased Sympathetic tone (Altered blood flow regulation)

Vascular Disease
- Microvascular: Structural: Capillary BM thickening, Capillary BM thickening, Functional: A-V shunting, Increased blood flow, Neuropathic edema
- Macrovascular: Atherosclerosis, Ischemia

Impaired Response to Infection

Amputation

Diabetic Foot Ulceration
DFU Evaluation Essentials

➢ Dermatologic Assessment
  - Interdigital area, skin quality, integrity, atrophy callus, ulcerative or pre ulcerative changes and toenails.

➢ Wound Assessment
  - Classification, culture, radiologic, R/O osteomyelitis

➢ Vascular Assessment
  - Pulses, toe and ankle pressures, TCOM’s, venous or arterial symptoms

➢ Neurological Assessment
  - Evaluate sensory perception, DTR’s, loss of protective sensation.

➢ Musculoskeletal Assessment
  - Deformities such as hammer toes, bunions, evaluate pressure areas, muscle strength, weakness, contractures, joint ROM and gait.
Classification
Diabetic Foot Wounds

The Ideal Classification System:

- Simplicity
- Directs Treatment
- Predicts Outcome
- Facilitates Communication
  - across all specialties
### University of Texas Health Science Center Diabetic Foot Wound Classification System

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre or postulcerative lesion (epithelialized)</td>
<td>Superficial, not involving tendon, capsule or bone</td>
<td>Penetrates to tendon or capsule</td>
<td>Penetrates to Bone</td>
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<tr>
<td>INFECTION</td>
<td>INFECTION</td>
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4 Grades (Depth) 0,1,2,3
4 Stages (Associated Comorbidity) A, B, C, D
Meggitt-Wagner Ulcer Classification System

0- Intact Skin
1- Superficial Ulcer
2- Deep to Tendon, Bone or Joint
3- Deep with abscess-ostitis
4- Forefoot Gangrene
5- Whole Foot Gangrene

Depth
Infection
Ischemia

Meggitt, Br J Hosp Med, 1975
Wagner, Foot Ankle, 1981
Diabetic Foot Ulcer Infections

➢ Commonly Polymicrobial
➢ Most common bacteria
  • Streptococcus Gram (+) this is most often found in DFU
  • Escherichia coli Gram (-)
  • Proteus Gram (+)
  • Pseudomonas Gram (-)
Is wound healing different in people with diabetes?

- Abnormal Cellular/inflammatory Pathways
  - fibroblasts, neutrophils, AGE’s
- Wound Hypoxia
  - Macrovascular disease
  - Microvascular disease
- Peripheral Neuropathy
  - Loss of protective sensation (LOPS)
  - Neuro inflammatory response
  - Autonomic dysfunction
Principles of Wound Care

All adjunctive wound healing modalities do not supplant the need for Good Basic Wound Care

- Off-loading
- Debridement
- Infection management
- Ischemia management
The 6 P’s of Ulcer Prevention

<table>
<thead>
<tr>
<th>TABLE 2. THE SIX PRINCIPLES OF PREVENTION OF FOOT ULCERS.*</th>
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</thead>
<tbody>
<tr>
<td>Podiatric care</td>
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<tr>
<td>Regular visits, examinations, and foot care</td>
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<tr>
<td>Risk assessment</td>
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<tr>
<td>Early detection and aggressive treatment of new lesions</td>
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<tr>
<td>Pulse examination</td>
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<tr>
<td>Evaluation for claudication and pain at rest</td>
</tr>
<tr>
<td>Assessment of foot pulses; noninvasive vascular testing when indicated</td>
</tr>
<tr>
<td>Protective shoes</td>
</tr>
<tr>
<td>Adequate room to protect feet from injury, well-cushioned</td>
</tr>
<tr>
<td>Walking sneakers, shoes with extra depth and width,</td>
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<tr>
<td>custom-molded shoes</td>
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<tr>
<td>Special modifications as necessary</td>
</tr>
<tr>
<td>Pressure reduction</td>
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<tr>
<td>Pressure measurements</td>
</tr>
<tr>
<td>Cushioned insoles, custom orthoses, padded hosiery</td>
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<tr>
<td>Prophylactic surgery</td>
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<tr>
<td>Correction of structural deformities: hammer toes, bunions,</td>
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<tr>
<td>Charcot’s foot</td>
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<tr>
<td>Prevention of recurrent ulcers over deformities</td>
</tr>
<tr>
<td>Intervention at opportune time</td>
</tr>
<tr>
<td>Preventive education</td>
</tr>
<tr>
<td>Patient education: need for daily inspection and early intervention</td>
</tr>
<tr>
<td>Physician education: importance of foot lesions, importance of regular foot examination, and current concepts of foot management in patients with diabetes</td>
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</tbody>
</table>

*Adapted from Frykberg.41
Progressive Risk of Ulceration

- **Group 0**: No Neuropathy - 5.1
- **Group 1**: Neuropathy - 14.3
- **Group 2**: Neuropathy, PVD and/or Deformity - 18.8
- **Group 3**: H/O Ulcer/Amp - 55.8

Peters 2001
Ulcer Prevention

- Prevent injury/trauma
- Aggressive treatment of hyperglycemia
- Treatment of deformity
- Neuropathy treatment
- Vascular evaluation
- Footwear / orthotics
- Ongoing diabetic care
  - callous, temperature, accommodation for deformity, visual inspection, education, venous disease
Amputation Prevention Program

➢ Podiatric Foot Care
  • Regular visits, exam, foot care
  • Risk assessment
  • Early detection and treatment of problems’

➢ Protective Shoes

➢ Pressure Reduction
  • Padded hosiery
  • Custom orthotics
  • Pressure mapping

➢ Prophylactic Surgery
  • Prevent recurrent ulcers
  • Correct structural deformity

➢ Preventive Education
  • Patient and Physician education

“it is not what you put on a diabetic foot ulcer... it’s what you take off”

~ Dr. David Armstrong
The Wound Care Center
Foot Ulcer Etiology

- Neuropathic
- Arterial
- Venous
- Pressure
- Surgical - Traumatic
- Atypical

Management of the ETIOLOGY
Wound Care Strategy

➢ Basic Wound Care
  • Wound Assessment and Classification
  • Optimization of Disease Management
  • Vascular Evaluation
  • Debridement
  • Off Loading
  • Compression Therapy
  • Moist Wound Healing
  • Infection Management

➢ Advanced Wound Care
Advanced Modalities/Therapies
(Alternative or Adjunctive Interventions)

Definition

Mechanical, Biological or Pharmaceutical modalities that are utilized when standard basic wound care protocols have failed to produce demonstrable improvement in wound healing, as evidenced by poor granulation development and a flattened wound healing trajectory, via mechanisms which stimulate perfusion or enhance angiogenesis...
Advanced Modalities
Utilization Algorithm

➢ Patient & Wound Assessment
➢ Basic Wound Care
➢ Follow up and Monitoring
Patient Selection Criteria

Negative Predictor at 4 Weeks

Sheehan et al. Percent change in wound area of diabetic foot ulcers over a 4-week period is a robust predictor of complete healing in a 12-week prospective trial. Diabetes Care. 2003;26:1879-1882.
Consensus Recommendations On Advancing The Standard Of Care For Treating Neuropathic Foot Ulcers In Patients With Diabetes

Robert J. Snyder, DPM, CWS
Robert S. Kirsner, MD, PhD
Robert A. Warriner III, MD, FACA, FCCP, FCCWS, ABPM/UHM
Lawrence A. Lavery, DPM, MPH
Jason R. Hanft, DPM, FACFAS
Peter Sheehan, MD
**TREATMENT**

**Debridement:** Cold steel surgical debridement initially and then as needed based on condition of the wound (maintenance)

**Infection control**
- Bacterial colonization ≠ infection
- Infection is diagnosed from clinical findings whenever possible. Purulent secretions are present or > 2 or at least two principal symptoms of inflammation (e.g., redness, warmth, swelling and pain or tenderness).
- Given that patients with diabetes are typically immunocompromised, clinicians should also look for secondary signs of infection including exudates, delayed healing, friable granulation tissue, discolored granulation tissue, foul odor, pocketing at the wound base and wound breakdown.
- Culture:
  - 1) Levine swab technique
  - 2) quantitative biopsy (for bone only)
  - 3) testing (not universally available) via polymerase chain reaction assay, oligonucleotide array

**Offloading**
- 1) Total contact cast (TCC)
- 2) Instant TCC
- 3) See Figure 2.

**Advanced therapies**
- Use 4-week treatment end point to assess need for advanced therapies
- If wound is not progressing toward healing (percent wound area reduction = 50%), then advanced therapies should be considered
- All previous assessment and treatment standards should continue to be utilized
Advanced Modalities
Utilization Algorithm

➢ Implementation of basic wound care strategies
➢ Close follow-up
➢ Decision Point 4 week
➢ Percent wound area reduction = 50%
Summary of HBO Mechanisms

Enhanced WBC Killing

Growth Factor Stimulation

Decreased Edema

Tissue Hyperoxygenation

Cellular Proliferation

Platelet Deformability

Neovascularization

Antioxidant Prevents IRI
Elective Indications

- Diabetic Wounds
- Radiation Injury
- Chronic Osteomyelitis
- Problem Wounds
  - Arterial insufficiency
  - Compromised flaps & grafts
- Emerging
  - PTSD, TBI
Approximate Distribution for Typical Outpatient Programs.

- Radiation 30%
- Diabetic 30%
- Flaps & Grafts 15%
- Osteomyelitis 15%
- Anaerobic 5%
- CO / AGE / DCS / Anemia 5%
Hyperbaric Oxygen Therapy Facilitates Healing of Chronic Foot Ulcers in Patients With Diabetes

OBJECTIVE — Chronic diabetic foot ulcers are a source of major concern for both patients and health care systems. The aim of this study was to evaluate the effect of hyperbaric oxygen therapy (HBOT) in the management of chronic diabetic foot ulcers.

RESEARCH DESIGN AND METHODS — The Hyperbaric Oxygen Therapy in Diabetic Patients with Chronic Foot Ulcers: A Randomized Controlled Trial was a randomized, single-center, double-blinded, placebo-controlled clinical trial. The outcomes for the group receiving HBOT were compared with those of the group receiving treatment with hypobaric air. Treadmills were given in a multi-place hyperbaric chamber for 90 min daily session (30 min at 2.5 ATA, 15 min at 2.0 ATA, and 15 min at 1.5 ATA) for eight weeks (40 treatments). The study was performed in an arbitrary setting.

RESULTS — Nineteen patients with Wagner grade 3, 4, or 5 ulcers, and those who had been present for 12, 24, 36, or 48 weeks were included. The improvement in the walking distance was achieved by 37 patients at the end of follow-up (75.6% in the HBOT group and 30.7% in the hypobaric group, P = 0.01). In a sub-analysis of all patients completing ≥21HBOT sessions, the incidence of ulcers decreased in 22.5% (13%) in the HBOT group and 27.5% (12%) in the placebo group (P = 0.08). The frequency of adverse events was low.

CONCLUSIONS — The HBOT study showed that adjunctive treatment with HBOT facilitates healing of chronic foot ulcers inselected patients with diabetes.

Diabetes Care 33:986-989, 2010

Diabetic foot ulcers are a common and serious complication of diabetes (1,2). Treatment often requires long-term hospital admissions and frequent hospital visits. Furthermore, the risk of mobility poses a great burden on the patient and the health care system. At centers of excellence, 90%-95% of ulcers are reported as nonhealing (4,5). Thus, despite improvements in healing diabetic foot ulcers, there is still a need for new treatment strategies and methods.

Cetomatic hyperbaric oxygen therapy (HBOT) has been proposed as a medical treatment for diabetic foot ulcers (6). HBOT has been demonstrated to have an

Hindawi Publishing Corporation

Clinical Care: Education/Nutrition/Psychosocial Research

Cite this article as: "Hyperbaric Oxygen Therapy Facilitates Healing of Chronic Foot Ulcers in Patients With Diabetes," Diabetes Care, 33:986-989, 2010.

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Set accompanying editorial, p. 1143.

995 Diabetes Care, volume 33, number 5, May 2010
care.diabetesjournals.org
HBOT in DFU

➢ Prospective RCT of 94 patients with DFU
  • Wagner Grade 2, 3, and 4
  • Randomized to HBOT vs Placebo Control
  • HBOT (N=48) Complete Healing
    ✓ 25/48 (52%)
  • Placebo Control Group (N=42)
    ✓ 12/42 (29%)  P=0.03
  • Patients completing >35 HBOTxs
    ✓ HBOT Group 23/38 (61%)
    ✓ Control 10/37 (27%)  P =0.009

HBO in DFU

➢ Prospective randomized study of 70 patients using HBO treatment in DFU
  • 35 Patients each group
  • HBOT Group
    ✓ 3 of 35 (8.6%) patients major amputation
    ✓ 1AKA, 2BKA
  • Control Group
    ✓ 11 of 33 (33.3%) patients major amputation
    ✓ 4AKA, 7BKA
  • P=0.016

HBO in DFU

Non randomized comparative study
- 184 consecutive patients with DFU
- HBOT adjunctive to standard of care

Results
- 115 (63%) Healed
- 31 (17%) No improvement
- 38 (20%) Amputation
  - 9 (4.9%) Major (BKA)
  - 29 Minor

Lack of Effectiveness of Hyperbaric Oxygen Therapy for the Treatment of Diabetic Foot Ulcer and the Prevention of Amputation

A cohort study

David J. Margolis, md, phd
Jayanta Gupta, md, phd
Ole Hoffstad, ms
Maryte Pappopoulos, ba

Henry A. Glick, phd
Stephen R. Thom, md, phd
Nandita Mitra, phd

significant improvement associated with HBO therapy and concluded that the overall quality of the reviewed studies was poor (8).
Study Summary

- Longitudinal observational data from the National Healing Corporation.
- The study goal was to compare the effectiveness of HBO to other therapies for DFU
  - prevention of lower extremity amputation
- Statistical analysis
  - Propensity Scores to determine the “propensity” that an individual was selected to receive HBO
  - Statistically controlled variables that might influence the selection of a therapy and thus to mimic the “even” distribution of variables seen in a RCT

Results

- 6,259 DFU with adequate lower limb arterial perfusion, and foot ulcer extending through the dermis
  - Propensity score–adjusted models, individuals receiving HBO were less likely to heal DFU
    ✓ hazard ratio, 0.68; 95% confidence interval, 0.63–0.73
  - And more likely to have an amputation
    ✓ hazard ratio, 2.37; 95% confidence interval, 1.84-3.04
  - HBO was not found to improve the likelihood that a wound might heal or to decrease the likelihood of amputation in any of these analyses

Conclusion

➢ Use of HBO neither improved the likelihood that a wound would heal nor prevented amputation in a cohort of patients defined by Centers for Medicare and Medicaid Services eligibility criteria.

➢ The usefulness of HBO in the treatment of diabetic foot ulcers needs to reevaluated.

Study Criticisms

- Excluded cohort had a higher rate of lower extremity amputations compared to literature
  - Suggests basic wound care was poorly conducted
- Detailed selection criteria for HBOT were not reported
  - Questions if HBOT patients were medically appropriate
- Included Wagner Grade 2 DFU
  - RCT evidence reports HBOT efficacy in Wagner 3/4 DFU
- Propensity and Sensitivity Analysis was inadequate to account for confounding variables
- Practice protocol of 1 company cannot be generalized
Clinical Correlations
HBOT Utilization Algorithm

➢ Patient & Wound Assessment
➢ Standard Wound Care
➢ Follow up and Monitoring
HBOT Utilization Algorithm

➢ Patient & Wound Assessment
  • Control of Major Chronic Disease Conditions
  • Nutritional Management
  • Vascular Interrogation & Intervention
Vascular Assessment

- Physical Examination
- ABI
- TCOM
- Duplex Ultrasonography
- Contrast Angiography
The Vascular Center

➢ Exercise Testing
➢ Non-Invasive Imaging
➢ Angiography
TCOM Clinical Guidelines

- 37 Patients undergoing BKA
- Preoperative TCOM evaluation
- $P_{TCo_2} = 0$ torr / All Failed
- $P_{TCo_2}$ 30 - 40 torr / 15 of 19 Healed
- $P_{TCo_2} > 40$ torr / All Healed

TCOM During HBOT

➢ Results: Overall 75.6% improved after HBO
  • Improved: 34 treatments (mean)
  • Not improved: 24 treatments (mean)
➢ Baseline TcPO2 (air 1 ATA) has almost no predictive value - multiple cut-off scores analyzed
➢ Single best discriminator of success or failure - TcPO2 during HBO2 > 200 mm Hg
  • Reliability 74%
  • Positive Predictive Value (PPV)- 58% (221 pts)

HBOT & Diabetic Foot Ulcer
CMS Coverage Indication
Diabetic Foot Ulcer

- Lower extremity wound due to Diabetes
  - Type I or Type II DM
- Wagner Grade III or higher
- Failed standard wound care
  - No measurable signs of healing for 30 days
  - Decrease in volume or size
  - Decrease in exudate
  - Decrease in necrotic tissue
Clinical Algorithm HBOT in DFU

1. Wagner III, IV or V

   NO

3. Deep ulcer with osteomyelitis, or abscess
4. Gangrene of toes or forefoot
5. Midfoot or hindfoot gangrene
Clinical Algorithm HBOT in DFU

Wagner III, IV or V

Standard Wound Care

30 Day Clinical Evaluation

Improved

NO Clinical Improvement

1 - Vascular Status?
2 - Correction of Vasc Problems?
3 - Nutritional Status?
4 - Glycemic Control?
5 - Debridement?
6 - Appropriate Dressing?
7 - Appropriate Off Loading?
8 - Resolution of Infection?

Begin HBOT
2.0 – 2.4 ATA
30 Day Re Eval
Case Studies
Initial Presentation

- 48 year old male PMH of HTN, IDDM, CRI
- Left 1\textsuperscript{st} MTP plantar foot ulcer 2 weeks
- Presented to WCC
  - Debridement, Offloading, Antimicrobial Topical
  - Vascular Center Referral
    - ABIs .9 BLE
  - Dietary Referral
  - X-ray Negative for Osteo
Initial Presentation

- 63 year old male PMH of CAD, IDDM
- Right plantar foot ulcer 2 months duration
- Presented to ED with cellulitis and distal foot ischemia
- Admitted
  - IV ABX
  - Surgical debridement
  - Open TMA
  - TCOM Evaluation
DFU  Necrotizing Fasciitis

- 48 year old male PMH of IDDM
- 3 month history of plantar ulcer
- Presented with septic left foot, fever
- Admitted
  - IV ABX
  - Surgical débridement
    - Operative diagnosis of necrotizing fasciitis
Thank You...