A series of case presentations identifying the improved clinical and cost outcomes that characterize the addition of hyperbaric oxygen therapy to standard medical and surgical measures, in carefully selected patients.

A 58 y/o BM with a history of diabetes mellitus was referred to the hyperbaric medicine service for evaluation and treatment recommendations for a chronic foot wound. The patient was initially diagnosed with neurotrophic fasciitis of the lower extremity for which he underwent debridement of necrotic tissue. He was subsequently found to have an underlying osteomyelitis with bone biopsies positive for Group B Streptococcus. Despite aggressive wound care, his wound failed to heal.

Significant Medical and Surgical History: Hyperbaric; insulin dependent diabetes mellitus (> 10 years); right ankle open reduction and internal fixation; repairs of a left patella fracture and a left shoulder rotator cuff.

Review of Systems: A well-healed surgical scar was present over the dorsal right leg. A 9 x 5 cm surgical incision was evident over the dorsum of the foot extending distally from the mid-foot to the fourth and fifth metatarsal heads. Exposed extensor tendon was also noted proximal to the 4th and 5th digits (Fig. 1). Granulation tissue was noted over the medial aspect of the surgical wound with a modest amount of firmness noted. The dorsalis pedis pulse was unobtainable secondary to the surgical incision transecting this area. A modest sensory polyneuropathy was noted.

Transcutaneous Oxygen Evaluations: A transcutaneous oxygen study was conducted. Peri-lesional tissue oxygen states during air breathing (21% oxygen) were consistent with modest hypoxia, sufficient in degree to adversely influence oxygen-dependent wound healing. Response to 100% oxygen inhalation was consistent with a modest arterial inflow compromise.

Assessment:
- Status post debridement
- Group B Strept osteomyelitis
- Wagner Grade 3 diabetic foot lesion
- Reversible wound hypoxia
- No patient specific risks for hyperbaric oxygenation
- Lack of an adequate healing response to standard care (debridement; L.V. Roehmian via PROD line; glycemic monitoring; local care with Panafil, offloading and elevation, wound vac,)

Recommendations:
- Institute daily hyperbaric oxygen, per diabetic foot wound treatment algorithm
- In-chamber transcutaneous oxygen study to confirm minimum required iVPO2 value of 200 mm Hg is exceeded
- Correlate following 20 treatments
- Maintain present local wound care

Those recommendations were agreed to by the patient and his primary/derating specialist. The informed consent process was completed. Hyperbaric treatment was initiated per protocol. Periound tissue oxygen levels recorded during the initial treatment were encouraging, exceeding 550 mm Hg. The second treatment was complicated by ear pain (secondary to chamber compression). ENT consult was obtained and ventilation tubes placed. No further ear discomfort was reported.

By treatment number seven a beefy granulation tissue filled the wound base (Fig 2). Treatments continued uneventfully.

By treatment number 20 granulation tissue filled the wound. Epithelialization was underway (Fig 3). At this point the patient appeared to be close to the point of maximum benefit from hyperbaric oxygen. It was elected to hold further therapy and follow the patient with weekly return visits to confirm sustained clinical improvement.

Those follow-ups, at week two (Fig 4) and week six (Fig 5) were consistent with an excellent healing response. The patient was discharged from the hyperbaric medicine service at this point, to the follow-up care of his primary care physicians.

Discussion:
Diabetic patients are particularly prone to wound healing deficiencies. Several factors serve to complicate the healing process and threaten the extremity, most notably hypoperfusion and local wound hypoxia (2). Transcutaneous oxygen testing serves to quantify any wound oxygen delivery shortcomings. In the context of the hyperbaric referral, transcutaneous oximetry will also identify those who have the physiologic capacity to respond locally to centrally delivered hyperbaric oxygen (by the process of a 100% oxygen challenge demonstrating blink reversal of post-wound hypoxia). Hyperbaric oxygen therapy has been demonstrated to accelerate healing wounds complicated by hypoxia (4), produce an enduring healing effect (5), and lower the incidence of amputation in diabetic patients (6).

The patient described above was instructional in several respects. His infective process was quickly identified, prompting hospitalization and aggressive surgical and medical management. His subsequent clinical course was complicated by a poorly healing surgical wound despite standard care. Referral to hyperbaric medicine was appropriate at this point, and consistent with clinical and insurance compliance standards. Local tissue hypoxia was identified as was its reversibility (approportion to undergo HBO therapy). In-chamber tissue oxygen values confirmed that the necessary therapeutic range of hyperoxypetation had been achieved. Healing responses were identified early in the treatment course and a therapeutic endpoint was reached at 20 treatments. HBO therapy was held at this point and continued spontaneous healing to complete resolution was recorded over the next several weeks.

In summary, the addition of hyperbaric medicine, applied along an algorithmic pathway, produced the necessary anergic and antimicrobial responses to heal an otherwise refractory soft tissue lesion in a patient at considerable risk for amputation.

References: (Available upon request)

HYPERBARIC MEDICINE SERVICE CASE OF THE MONTH

<table>
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<tr>
<th>Indications</th>
<th>Rationale</th>
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<tr>
<td>Acute carbon monoxide poisoning</td>
<td>Augment host antimicrobial defenses; induce angiogenesis; potentiate leukocytic dismutase superoxide and peroxide production; extend post-antibiotic effect; augment osteoclast activity</td>
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<tr>
<td>Acute thermal burns</td>
<td>Relieve hypoxia; decrease fluid losses; limit burn wound extension and conversion; treat edema; promote wound closure</td>
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<tr>
<td>Acute ischemia</td>
<td>Overcome free gas volume-induced ischemia; relieve hypoxia; enhance leukocytic dismutase superoxide and peroxide production; reduce exudate; promote wound closure</td>
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<tr>
<td>Acute necrotizing soft tissue infections</td>
<td>Correct diabetic-induced leukocyte changes; prepare for definitive surgical intervention; eliminate necrotizing processes; demarcate potentially viable tissue</td>
</tr>
<tr>
<td>Necrotizing soft tissue infections</td>
<td>Support surgically perfused/infused tissue; eliminate ischemic-reperfusion injury; facilitate angiogenesis; correct diabetic-induced leukocyte changes; prepare for definitive surgical intervention</td>
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