

MANAGEMENT OF DIABETIC FOOT USING HYPERBARIC OXYGEN

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ABSTRACT

Objective: To review the effectiveness of systemic hyperbaric oxygen therapy in addition to a comprehensive treatment protocol in the management of diabetic patients to reduce the amputation rate for severe foot ulcers.

Methods: From October 1996 to October 2000, 60 diabetic patients aged 42 to 64 years (mean age, 52.2 years) were admitted to the hyperbaric department at Princess Haya Al-Hussein Hospital for diabetic ulcers. All subjects were candidates for limb amputation, 25 of them had undergone one amputation at least, before our therapy was started, and they were scheduled for further amputations. All of them were treated using hyperbaric oxygen therapy in our department as the last choice.

Results: Of the treated group (mean session = 25.2), fifty-two (86.7%) patients completely recovered from diabetic foot, three subjects (5%) underwent below knee amputation, and five patients (8.3%) did not respond to hyperbaric oxygen therapy.

Conclusion: Systemic hyperbaric oxygen therapy, in conjunction with an aggressive therapeutic protocol, and the cooperation of patients, are effective in decreasing the rate of major amputations in diabetic patients with highly prevalent ischemic foot ulcers.

Key words: Hyperbaric oxygenation, Diabetes mellitus, Foot ulcer

JRMS June 2003; 10(1): 45-48

Introduction

Diabetic foot wounds are one of the major complications of diabetes, resulting in substantial morbidity and mortality⁽¹⁾. One mode of therapy is hyperbaric oxygen therapy (HBOT), which has been used for the last 20 years. This therapy is designed to increase oxygen delivery to local ischemic tissue and, by a variety of primary and secondary mechanisms, to facilitate wound healing in the high-risk foot. The aim of this study was to show the efficacy of HBOT in reducing the amputation rate for diabetic foot.

Methods

Between October 1996 and October 2000, a total of 60 diabetic patients aged 42 to 64 years (mean age, 52.2 years) with below knee unhealed and complicated wounds were admitted to our hyperbaric department at Princess Haya Al-Hussein Hospital. These patients were referred mainly from military hospitals. All patients had

non-insulin dependent diabetes mellitus, but 48 (80%) were on Insulin after starting their therapy.

The hyperbaric center has a multiplace chamber and double lock. The main chamber can take up to 6 patients in the sitting position or two patients in the supine position. The ante-chamber can take one person in the sitting position.

The file record includes general data about the patient: age, sex, income level, education level, type of diabetes, duration of the diabetes, and the duration of the trauma. Also patient's complete examination including lower limb vascular assessment, vital signs, ear, nose and throat, ophthalmic, cardiovascular, respiratory, neurological and lower limbs vascular assessments. The wound assessment data included the location, length, width, and depth of the wound, the skin discoloration, the color, odor, and the type of discharging fluid. The diagnosis of infection was made by culture taking the sample using and clinical criteria. If bone was exposed, with the presence of local or systemic infection, X-ray

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Manuscript received November 12, 2001. Accepted April 3, 2002

and bone biopsy were performed with both microbiologic and histologic analysis to diagnose or exclude osteomyelitis. A working diagnosis of lower-extremity ischemia was made by a combination of clinical and noninvasive vascular studies. Clinical signs were based on the absence of one or more foot pulses of the involved foot. Noninvasive criteria were based on the Doppler evaluation, but transcutaneous oxymeter was not available in our center. Some of those patients had undergone angiography and performed bypass surgery in their referral hospitals. Wounds were graded by depth according to the Wagner Classification⁽²⁾ (Table I). Our policy in treatment is to do the first ten HBOT sessions twice daily at 3- Absolute Atmospheric pressure (ATA) if there is possibility of osteomyelitis, or at 2.5 ATA if there is no osteomyelitis. The standard for each session is 90 minutes oxygen, followed by reevaluation of the wound. If there is improvement a daily session is continued, till twenty. Leaving the patient for one week and then the wound is reevaluated. If there is a good progression achieved the patient is left under strict follow-up with daily dressing. If there is stopping in the healing another ten sessions are continued. Then HBOT is stopped for ten days, if there is still good healing, we continue without HBOT, but if there is no improvement, we continue HBOT for another 10 sessions. If improvement was noted, treatment continued for an additional 10 sessions at 2.5 ATA, but if no improvement HBOT was discontinued. This kind of protocol therapy is used by many other hyperbaric centers like the Hyperbaric Medicine Unit, Institute for Exercise and Environmental Medicine, Presbyterian Hospital, Dallas⁽¹⁾, and the Hyperbaric Center of Southern Illinois University School of Medicine⁽³⁾.

Complete daily follow-up and good care were available to all patients treated in our department, including inpatients and those who were treated as outpatients. Our treatment was based on three parts, the first on hyperbaric benefit, the second was on enhancement of patient cooperation, and the third based on two branches; the first one on the patient care, including behavioral modification, dietary modification, smoking cessation, antibiotics intake, tonics intake, and glycemic control, and the second branch was based on wound care, wound assessment, debridement using surgical or chemical methods according to the severity of the debris and necrotic tissues, washing with normal-saline, and daily dressing with antibiotic cream using Silver nitrate cream, Nitrofurantoin cream, or a mixture of both. In some cases mainly in toes, wounds were treated by antimycotic cream.

All subjects were candidates for limb amputation in different levels after all standard modalities of treatments were tried to salvage the affected limb, however, most of them had done at least one amputation without healing response and with severely infected or gangrenous areas. HBOT was the last extra choice for possible treatment before amputation.

Patients were enrolled in a rather aggressive management protocol, consisted of extensive local wound management, general patient management and HBOT which started in the first or in the next day of admission according to their tolerance to the hyperbaric chamber. Strict daily follow-up and general patient care were available to all patients whether inpatients or outpatients.

Results

Of the treated group, using number of hyperbaric oxygen treatment sessions (mean session=25.2); 52 patients (86.7%) had complete healing of their wounds. Follow-up included the color of the edges of the wound, the decreased pus discharge or exudate, the infection of the wound in general, and the refilling pressure of the affected limb distally or near the wound; according to these measures, three subjects (5%), underwent major amputation, and 5 patients (8.3%) did not benefit after 10 HBOT sessions and had to stop their hyperbaric oxygen treatments. All wounds were infected by different species of bacteria. 70% of wounds were infected with Staph aureus, 60% infected by Streptococcus, SP 55% with mixed bacteria, while 20% of wounds were infected with Pseudomonas (Fig. 1).

Nineteen patients (32%) received 21-30 sessions, and one patient (1.7%) was treated with 63 hyperbaric sessions (Fig. 2).

Four out of five patients who had undergone femoro-popliteal artery bypass were treated successfully with up to 35 hyperbaric sessions.

Follow-up of these patients over 1-5 years has shown that 2 patients (3.33%) had relapsing symptoms, one patient underwent below-knee amputation and the other had further surgical interventions on his forefoot.

Discussion

Many retrospective studies have shown the efficacy of HBOT, but this is the first one on the efficacy of HBOT in treating diabetic feet in Jordan.. A study conducted by Armstrong *et al* reviewed the medical records of 360 diabetic patients presenting for care of foot wounds at a multidisciplinary tertiary care foot clinic⁽⁴⁾. Of all patients presenting for care, the success rate was 71%, however, 29% received some form of lower extremity amputation. The study by Wattel *et al* showed that in 20 patients with non-healing wounds, 11 of them who had diabetes were healed from the ulcers, without amputation with a salvage rate of 75%⁽⁵⁾. Baroni and associates prospectively treated 28 patients, 16 of the 18 patients (89%) who were treated with HBOT in the treatment group completely healed and remained healed at a follow-up of 1-36 months⁽⁶⁾. In a consecutive study over 70 patients, 35 of them were treated with HBOT. Faglia *et al* reported 3 (8.6%) subjects who underwent major amputation, with a success rate of 91.4%⁽⁷⁾.

The double-blind study by Abidia *et al*⁽⁸⁾ showed that at 12 weeks, healing with complete epithelialisation was

achieved in 13 out of 19 ulcers in the treatment group compared to 4 out of 14 ulcers in the control group.

Our study (Fig. 1) showed the highest success rate, which is around 90%. We believe that this result was due to the combination of multiple HBOT sessions; the good local wound care, general patient management and the continuity of hyperbaric oxygen therapy until the achievement of full wound healing. In our treatment a lot of additional benefits like disappearance of peripheral neuropathic symptoms, good vascularity of the lower limbs, and improvements of many symptoms related to old cerebral vascular accidents, were achieved.

Conclusion

Hyperbaric oxygen therapy in conjunction with aggressive local and general management protocols, and cooperation of patients, was effective in decreasing the rate of major amputations in diabetic patients with highly prevalent ischemic foot ulcers. Good orientation of both physicians and patients is very specific in reducing the incidence of diabetic foot. A basic knowledge of (HBOT) is needed to refer the diabetic foot patient for treatment when indicated.

Table I. The Wagner Classification

Grade	Description
Grade -0	Pre-ulcerative lesion, healed ulcers, presence of bony deformity
Grade-1	Superficial ulcer without subcutaneous tissue involvement
Grade-2	Penetration through the subcutaneous tissue (may expose bone, tendon, ligament, or joint capsule)
Grade-3	Osteitis, abscess, or osteomyelitis
Grade-4	Gangrene of the forefoot
Grade-5	Gangrene of the entire foot



Fig. 1. Wound infection

No. of patients

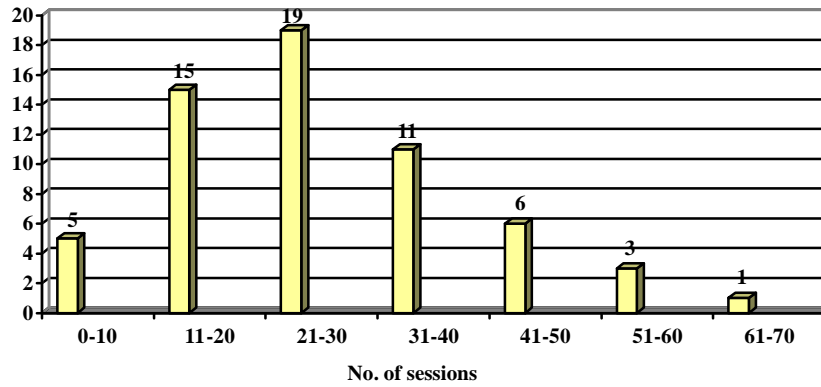


Fig. 2. Distribution of HBOT sessions.

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