The use of hyperbaric oxygen therapy and LEDtherapy in diabetic foot

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ABSTRACT

Chronic foot ulcers are common ailments presented in diabetes, which offer severe complications and are often unresponsive to therapy. In this work it was evaluated the effects of adjunctive Hyperbaric Oxygen Therapy (HBO) treatment and LEDtherapy irradiation on ulcer healing (HBO) in addition to conventional treatment. In ulcers of diabetic foot these treatments lead to a reduction in the probability of amputation up to almost four times compared with patients not receiving such co-adjutant treatment. The LEDtherapy irradiation was given concurrently using an energy density of 4J/cm² for 5 min. During the experiment nine patients with diabetic foot ulcers were submitted for HBO sessions with 2,5 ATM for two hours. The experiment demonstrated the effectiveness of HBO + LEDtherapy treatment by favoring the ulcer healing through a increased fibroblastic response, collagen synthesis and neo-vascularization of the ischaemia, as well as increases in the leukocytic bactericidal activity.

Keywords: Hyperbaric Oxygen Therapy; LEDtherapy; Diabetic foot ulcers; Healing.

1.INTRODUCTION

Diabetes mellitus is one of the major contributors to chronic wound healing problems. When diabetic patients develop an ulcer they become "high risk" with major complications. The patho-physiologic relationship between diabetes and impaired healing is complex. Vascular, neuropathies, immuno-function and biochemical abnormalities each contribute to altered tissue repair.[1]

Foot ulcers and their complications are an important cause of morbidity and mortality in diabetes.[2] Moreover, the costs of chronic complications proceeding from this disease are alarming.[3] Becoming therefore necessary to take primary prevention of the illness and to perfect treatment techniques, aiming to prevent appearance of complications.[4] The foot ulcer treatment is difficult, prolonged and often unsuccessful, and patients are often prone to serious complications. Systemic hyperbaric oxygen (HBO) therapy and Low energy laser therapy has been used as an additional method to treat various difficult wounds including diabetic foot ulcers.[5]

HBO therapy is defined as a mode of medical treatment in which the patient is entirely enclosed in a pressure chamber, breathing 100% O_2 at a pressure greater than 1 ATM (or 1 bar).[6] The most important effects of hyperbaric oxygen are stimulation of leukocyte activity, the enhancement of fibroblastic replication, increased collagen formation and neo-vascularization of ischemic tissue. Pre-operative hyperbaric oxygen induces neo-vascularization in tissue with radio-necrosis. Refractory osteomyelitis and necrotizing fascitis appear to respond to additional hyperbaric oxygen. Hyperbaric oxygen in burn injuries shortens hospital stays, reduces frequency of surgery, and decreases fluid replacement.[7] Hyperbaric oxygen can be administered in a single or multiple patient situation. These chambers are filled with compressed air, patients breathing 100% oxygen though face masks hoods or endo-tracheal tubes. Single chambers are less costly than their larger counterparts and allow hospitals to institute HBO programs without prohibitive capital outlays. Most chambers are sized to allow a single patient to lay in the supine position, the internal environment of singular chambers is maintained at 100% oxygen, thus relieving the patient of wearing a mask. [8,9]

A partially raised oxygen pressure (3 ATM) provokes toxicity to the central nervous system, with the visual and auditory symptoms, muscular nausea, tremors and convulsive irritability. Subjecting patients to thirty minute sessions at 100%

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oxygen with a 6 ATM pressure, presents a significant neural loss.[10]

In the course of the past two decades, many studies have been conducted to investigate wound healing after irradiation with low-power laser light. Researchers have hoped for improved and accelerated wound healing by the use of low-power laser light. Many studies reported accelerated and enhanced wound healing. However, several investigators were unable to repeat these results. The power output of the laser used as well as the wavelength of the emitted laser was different for the various studies.[11] The benefit of laser therapy is that laser radiation has a wavelength-dependent capability to alter cellular behavior in the absence of significant heating. Accelerated wound healing and hair growth were among the first effects reported, and early investigators believed that laser radiation "stimulated" the biological processes. As a result, the phenomenon was initially termed "biostimulation". However, as it was found that low intensity radiation could inhibit as well as stimulate cellular activity, the terminology was changed. Today, the term "biostimulation" has been replaced with an array of nearly interchangeable descriptive phrases such as low intensity, low level, and low power characteristics of the approach. In practice, laser therapy typically involves the delivery of 1-4 J/cm^2 to treatment sites with lasers having output powers between 10mW and 90mW.[12]

Many of the chronic complications of diabetes mellitus involve defects in connective tissue such as poor wound healing, diminished bone formation, and decreased linear growth. The wound healing abnormalities of diabetes mellitus results from several causes. When carbohydrates are unavailable to cells, for normal aerobic metabolism, oxidation of amino acids for caloric needs results in amino acid and protein depletion. The poor wound healing of diabetes mellitus has been shown to be associated with decreased amounts of collagen fibrils and collagen production. Hiperglycemia interferes with ascorbate transfer into fibroblasts and leukocytes, which also impairs the healing response. Impaired fibroblast and endothelial cell proliferation, epithealization, decreased collagen deposition, and reduced strength, are also characteristic deficits observed in streptozocin-induced diabetic animals. Animal experiments have suggested an enhancing effect of low power laser on wound healing, and this was supported by some preliminary clinical studies.[13] The LEDtherapy, which wavelenth is not delimited, shows the same efficiency as the low power laser therapy, which has a wavelength specifity.[14] On the other hand, the coherence and collimation, do not represent such crucial role, since quickly degrade by the scattering of the beam when tissue penetration occurs.[15]

2.METHODOLOGY

The present study was carried out on patients who were under HBO therapy at the Clinica BAROMED - São José dos Campos - Brazil. The hyperbaric chamber was used in a multi-patient situation, with capability of simultaneous treatment of up to ten patients. The LED-Light treatments were performed in each patient with the use of LED light with a wavelength in the spectral band and energy levels of 630-650 nm, 10 mW/cm^2 (4 J/cm^2). The evaluation files of nine patients contained personal data, pictures and the descriptions of the lesion area, for each group session of 10, 20 and 30 minutes (eight of masculine sex and one of feminine sex, with ages varying between 50 to 65 years). The patients had been treated for 13 consecutive weeks. The sessions of HBO were carried out six times per week, with a duration of two hours per session, using pressurization quota of 2,5 ATM. The LEDtherapy sessions occurred three times per week, the HBO sessions taking place immediately after. The sample group was divided into two sub-groups, one that the only treatment received was HBO and the other was HBO+LEDtherapy.The HBO group consisted of six patients, five male and one female, and in the HBO+LEDtherapy three male patients.

3.RESULTS

For the patients who had been submitted to HBO+LEDtherapy sessions , the benefits promoting extensive wound healing, is shown in Figures 1 and 2.

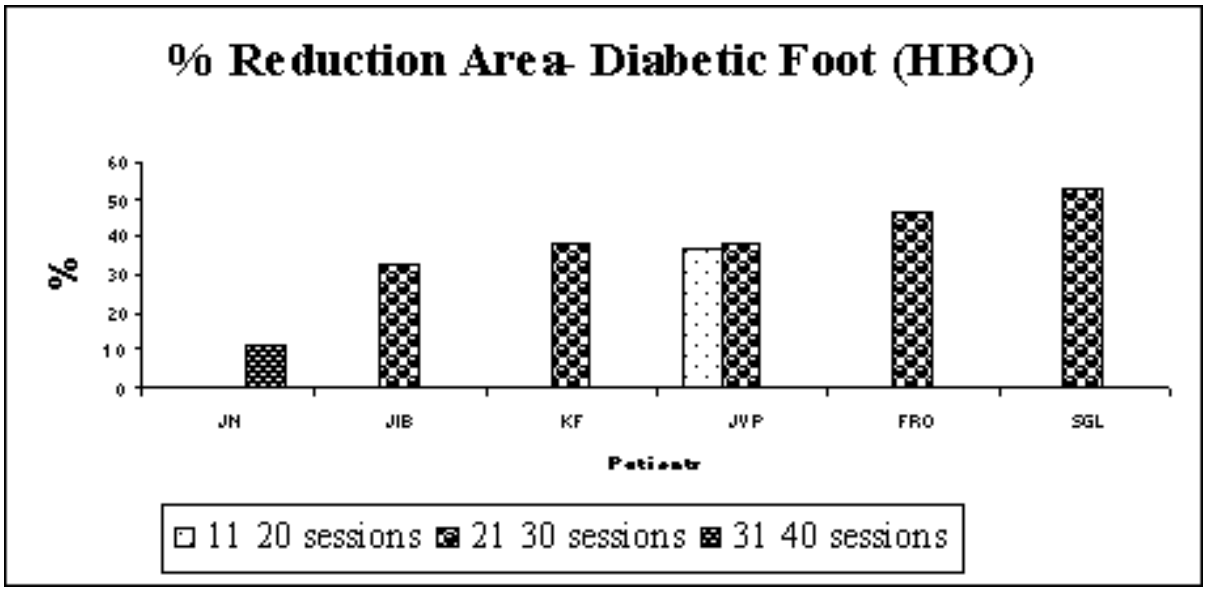

Fig. 1. Area reduction in diabetic foot after treatment with HBO.

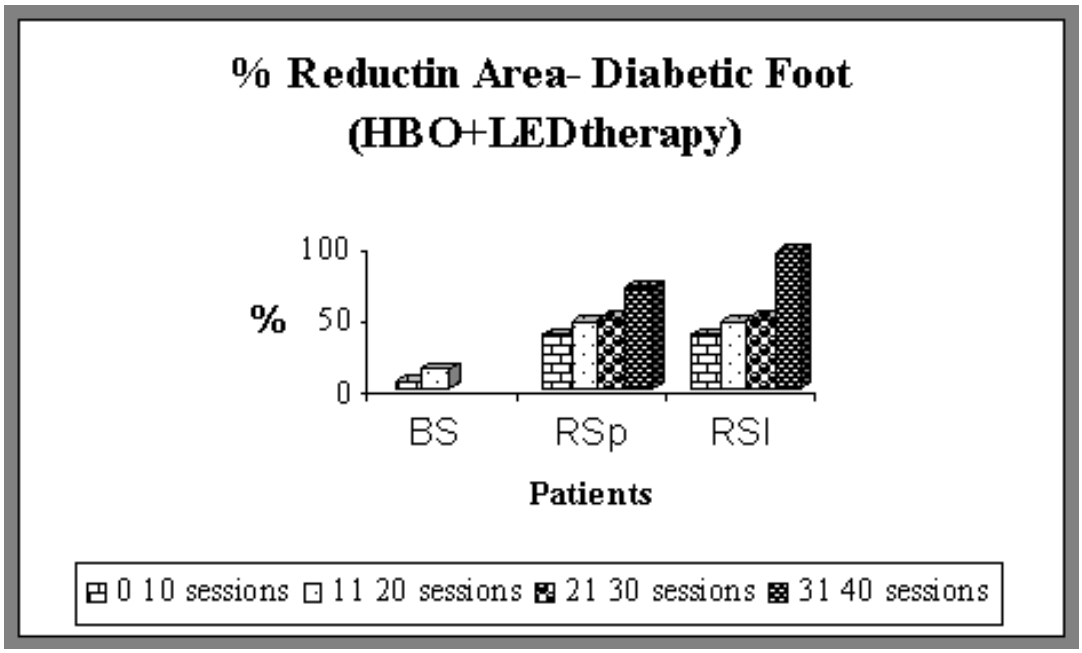

Fig. 2. Area reduction in diabetic foot after treatment with HBO+LEDtherapy.

The Figures 3a, 3b, 4a and 4b documented a difference between the treatment HBO and HBO+LEDtherapy, showing benefits promoting process healing in diabetic foot ulcers with treatment HBO+LEDtherapy. Figure 3 shows diabetic foot with (a) zero sessions and (b) after 40 sessions of HBO.

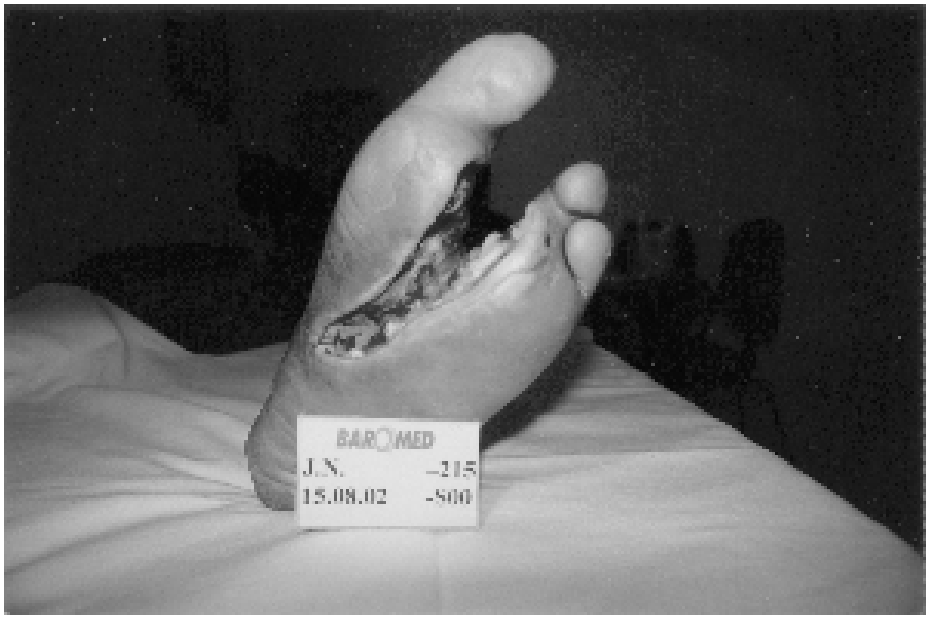

Fig. 3a. 0 sessions HBO.


Fig. 3b. After 40 sessions of HBO.

Figure 4 shows diabetic foot with (a) zero session and (b) after 40 sessions of HBO+LEDtherapy.

Fig. 4a. 0 sessions HBO+LEDtherapy.

Fig. 4b. 40 sessions HBO+LEDtherapy .

The figures 3a and 3b show the efficiency of HBO in promoting the healing process in diabetic foot , the figures 4a and 4b show the benefit of applying LEDtherapy in conjunction to HBO.

4. DISCUSSION AND CONCLUSION

Normal wound healing proceeds in three overlapping phases: inflammation, granulated tissue formation, matrix formation and remodeling. These processes are believed to be required in the interaction of cells in the dermis and epidermis as well as chemical mediators released from inflammatory cells, fibroblasts, and keratinocytes. Although precise normal wound healing is not well understood, a number of conditions such as diabetes mellitus, immuno-deficiency and venous stasis are.[13] The cause of diabetic foot ulcers is multi-factor, leading to functional disturbances in the macro-circulation and skin micro-circulation.[15] Diabetic foot problems are primarily due to disturbed micro-circulation causing considerable morbidity and costs, and their significance for the individual, as well as for society, is evident from a variety of publications concerning the socio-economic aspects of these disorders.

Recent research provides evidence that endothelial and smooth tissue dysfunction contribute to impaired microcirculation in patients with diabetes, the major functional abnormality being the marked limitation of micro-vascular vaso-dilatation. In association with the neuropathy; disturbed microcirculation is responsible for the development of diabetic gangrene, ulcers and infections of both skin and bone in long-term diabetic patients. The risk of diabetic micro-angiopathy has been shown to be correlated with the patient's glycemic control as measured by glycosylated hemoglobin.[16]

Adding HBO therapy and LEDtherapy to the multi-disciplinary conventional modalities is based on previous biological and early clinical observations.[5] The results are even more striking considering the fact that conventional therapy failed with these patients. Nevertheless, subsequently, at about 13 weeks only of adjunctive HBO and LEDtherapy was sufficient to achieve a greater advance in the process of healing only in the HBO group. Treating diabetic foot ulcers with hyperbaric oxygen stimulates fibroblast growth, increases collagen formation, promotes rapid capillary growth, and through these effects stimulates wound healing. In the LED therapy, the skin around the ulcer which was irradiated changed in color to pink, probably due to the vasodilatation, promoted greater collagen synthesis, neovascularization and increased leukocytes activity in the patients treated with HBO + LED therapy.

A rigorous clinical evaluation of its use must be carried out. HBO + LED therapy promotes shorter healing time, with low treatment costs, promotes shorter recovering time, enabling patients to return to their habitual activities sooner, reduces the possibility of amputation of members and improves quality of life. HBO + LED therapy has its use qualified in refractory injuries in usual clinical treatment.

It was concluded that in conjunction with standard treatments, the added application of HBO + LED therapy may have a true beneficial effect on the natural history of chronic therapy-resistant diabetic foot ulcers. This is also reflected in the low prevalence of reulceration.Treatment with HBO + LED therapy is simple, inexpensive, and can easily be adopted by primary health care facilities. Thus, the main conclusion is that these preliminary results should stimulate interest in adjunctive treatment HBO + LED therapy for chronic foot ulcers in diabetic patients, and should lead to large-scale randomized controlled trials in the future.

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