Extracorporeal Shockwave Treatment for Chronic Diabetic Foot Ulcers

Background and Purpose: Diabetic foot ulcer is caused by ischemia/hypoxia due to occlusion of small vessel associated with neuropathy and secondary infection. Extracorporeal shockwave treatment (ESWT) was shown to induce the improvement of neovascularization associated with increased angiogenic factors such as eNOS, VEGF and PCNA. Recent studies reported the effectiveness of ESWT in acute and chronic wounds. Others demonstrated the antibacterial effect of ESWT in experimental studies. It is reasonable to speculate that ESWT may be effective in diabetic foot ulcer patients. The purpose of this prospective study was to evaluate the efficacy of ESWT in chronic diabetic foot ulcers and to compare the results with that of hyperbaric oxygen (HBO), and to investigate the regeneration effects after treatment.

Methods: Seventy patients with 72 chronic diabetic foot ulcers were randomly divided into two groups. The ESWT group consisted of 34 patients with 36 ulcers and 36 patients with 36 ulcers in the HBO group. Both groups showed similar demographic characteristics. Patients in ESWT group received 3000 impulses of shockwave at 0.11 mJ/cm² energy flux density once every two weeks for 6 weeks. Patients in HBO group received HBO therapy in a sealed chamber at the pressure of 2.5 ATA once a day, 5 days for a total of 20 treatments. Local blood flow perfusion, bacterial culture, and biopsy were performed before and after treatment. The evaluations included clinical assessment on the healing status of the ulcer with photo-documentation, blood flow perfusion scan, bacteriological study, histomorphological examination and immunohistochemical analysis.

Results: The overall results showed completely healed in 31%, improved in 58% and unchanged in 11% for the ESWT group; and 22% completely healed, 50% improved and 28% unchanged for HBO group in favor of ESWT group (P < 0.001). ESWT group showed significantly better local blood flow perfusion rate (Table 1, Fig. 1-a and Fig. 1-b) and considerably higher cell proliferation and more active proliferation and than HBO (Fig. 2-a and Fig. 2-b). The results of bacteria culture revealed significant decreases in the bacteria colony counts after treatment (Table 2). On immunohistochemical analysis, ESWT group showed significant increases in eNOS, VEGF and PCNA expressions and a decreased TUNEL expression than the HBO group (Table 3, Fig. 3-a, -b, -c and -d).

Discussion: The cause of diabetic foot ulcer is multi-factorial including ischemia/hypoxia, neuropathy, and infection, and they often coexist. Management of chronic diabetic skin ulcers requires multidisciplinary approach including the control of diabetes, antibiotic, shoe wear, wound care and surgical interventions. The results of the customary standard treatments are inconsistent and most are less satisfactory. Therefore, many adjunctive therapies are designed with the intention to cure the diabetic foot ulcers including hyperbaric oxygen therapy, ultrasound, recombinant platelet-derived growth factor-BB, vacuum assisted closure, negative-pressure wound dressing and HBO. Out of many, HBO is the most commonly used modality. Some studies showed beneficial effects, however, none showed universal success. The results of the current study showed that ESWT is more effective than HBO in chronic diabetic foot ulcers.

The exact mechanism of ESWT remains unclear. The results of this study showed that clinical improvement of the ulcers after ESWT were associated with increases in angiogenesis and improvement in local blood flow perfusion, and decreases in cell apoptosis and bacteria growth.

Conclusions: ESWT is more effective than HBO in the treatment of chronic diabetic foot ulcer. It appears that application of this technique results in tissue regeneration in chronic diabetic foot ulcers.

References: