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M. Stieger[1] · J.-P. Schmid[2] · S. Bajrami[2] · T. Hunziker[1]
[1] Dermatology Clinic, Bern University Hospital and University of Bern, Switzerland
[2] Department of Cardiology, Cardiovascular Prevention & Rehabilitation, Bern University Hospital and University of Bern, Switzerland

Extracorporeal shock wave therapy in the treatment of a non-healing chronic venous leg ulcer

Medical history

A 56-year old female patient presents with a history of a venous leg ulcer for at least 6 years on the pretibial/lateral aspect of the right lower leg. Various aetiologies have been identified in this case. A duplex ultrasound conducted in 2005 revealed chronic venous insufficiency, which was treated surgically by crossectomy and stripping of the great saphenous vein. Moreover, the patient has also been diagnosed as having severe lipoedema with secondary lymphoedema and morbid obesity (class III, BMI of 60 kg/m²). Peripheral arterial disease was excluded by a normal ankle-brachial index (ABI) and normal great toe blood pressure. Various treatments with regular surgical wound debridement, ongoing compression therapy with short-stretch bandages and zinc oxide paste bandages, vacuum therapy (VAC), a wide variety of wound dressings (among which alginate dressings and hydrocolloids) and even two applications of Apligraf® were performed, but none of them led to sustained healing. Radical ulcer debridement was not considered to be indicated in the obese patient and was also declined by the patient. The otherwise healthy patient has no pain and is mobile despite her weight. She does not require any regular medication.

Skin status

A severely fibrotic, partially fibrin-coated ulcer with a size of 15x10 cm exhibiting minimal granulation, severe perifocal reddening and maceration extends from the pretibial part of the right lower leg to the lateral calf (**Fig. 1**). Peripheral pulses are well palpable and motor and sensory functions are intact on all sides. The wound swab taken merely confirmed the presence of skin flora. Malignancy was excluded histologically.

Therapy and progress

Owing to the therapy-refractory nature of the condition and exhaustion of all conservative and proliferation-stimulating wound management treatments, we decided to perform an adjuvant extracorporeal shock wave therapy. With the patient's consent, we continued conventional wound treatment with repeated surgical debridement and compression therapy with zinc oxide paste bandages, while at the same time performing local extracorporeal shock wave therapy (ESWT). After cleaning the ulcer, we applied sterile ultrasound gel and covered it with polyurethane film. Additional ultrasound gel was applied on the film to enhance shock wave transmission. Treatment was performed with the DUOLITH SD1® shock wave system (from Storz Medical AG, Switzerland), which is extensively used in the management of various orthopaedic pain syndromes (tennis elbow, heel spur, insertional tendinopathy). In order to achieve a significant effect, we applied 2000 shocks at an energy flux density of 0.25 mJ/mm² and a shock frequency of 4 Hz. Treatment was performed on a total area of about 200 cm², which included the approximately 150 cm² wound area plus the wound margins. The patient did not report any pain during the procedure. After completion of shock wave application, the wound was cleaned again and covered with hydrofibre wound dressing (Aquacel®) and zinc oxide paste bandages. Shock wave treatment was

Fig. 1 ▶ Fibrinous wound base, minimal granulation, periwound maceration

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Fig. 2 ▲ Substantial wound granulation after 5 extracorporeal shock wave therapy (ESWT) sessions

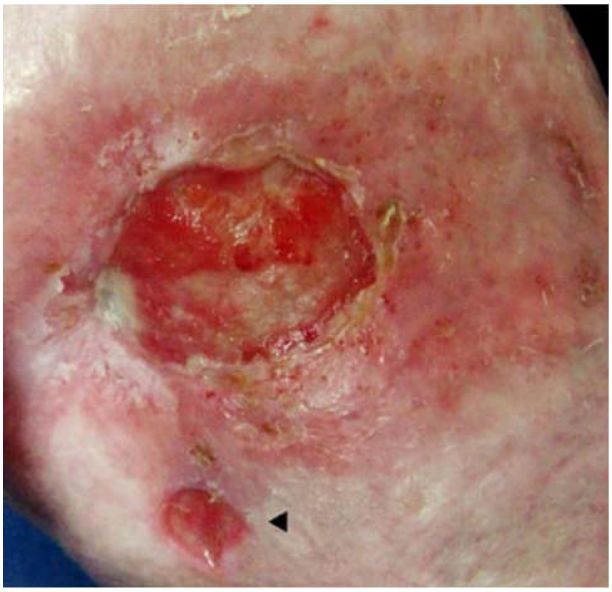

Fig. 3 ▶ Progressive re-epithelialisation. Formation of lymphatic fistulae *(arrow)*

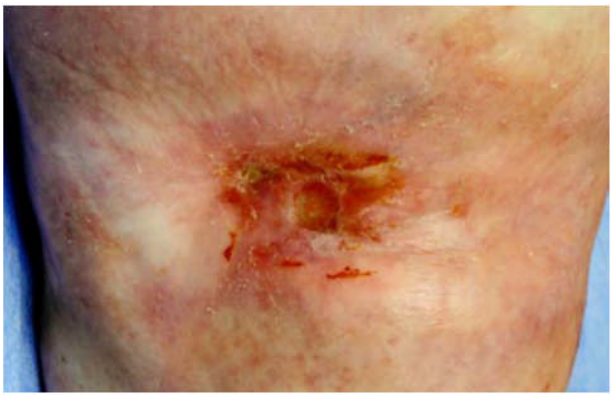

Fig. 4 ◀ Recurrent ulcer after complete epithelialisation before surgical coverage with a split-thickness skin graft

performed at weekly intervals. Progressive wound granulation and re-epithelialisation from the wound margins towards the centre of the lesion could be observed after merely 5 treatments (◘ **Fig. 2**). Complete re-epithelialisation was achieved after a total of 30 sessions. However, only a few weeks after the treatment had been discontinued the ulcer recurred, lymphatic congestion increased and vesicles were found similar to those in lymphangioma cutis (◘ **Fig. 3**). When ESWT was resumed and extended to include the proximal lower leg in order to achieve a potential improvement in lymphatic drainage, the lymphatic obstruction diminished while a small 3x3 cm superficial ulcer persisted. Since the wound area had reduced substantially, it was possible to completely close the remaining lesion by surgical coverage with a split-thickness skin graft (◘ **Fig. 4**).

Discussion

Extracorporeal shock waves are defined as a sequence of acoustic pulses that are characterised by a fast pressure rise to over 100 MPa, followed by a decrease to normal pressure within a few microseconds. Three different physical principles (electrohydraulic, electromagnetic and piezoelectric methods) can be used to convert an electric high-voltage pulse into a pressure wave, which is then bundled and transmitted in the form of a shock wave [1]. In urology, extracorporeal lithotripsy (ESWL) has been used with great success for over three decades as a non-invasive, safe procedure for the treatment of kidney stones. Mechanical shock waves penetrate the human tissue without causing damage. They are focused on the kidney stone for local fragmentation [2]. Shock waves used in the treatment of dermatological conditions have a wider focus, which means that the energy level is reduced, but the size of the target area that can be treated is extended [5, 7]. The fact that bone growth increases and accelerates as a result of ESWL treatment was discovered by pure coincidence [3]. The hypothesis that mechanical shock waves induce a biological reaction in body cells has been corroborated by a number of basic research studies. This process, also referred to as biomechanical transduction, has a series of beneficial effects on wound healing [4].

Several case studies confirm the positive effects of extracorporeal shock wave therapy in the management of chronic wounds [1, 5, 6]. In a prospective study of 208 patients with non-healing acute or chronic wounds of different aetiologies, Schaden et al. [7] found that complete epithelialisation was achieved with ESWT in 75% of the subjects treated (ulcer size between 4 and 16 cm^2, energy level 0.1 mJ/mm^2, 100 shocks/cm^2, 2 to 4 ESWT sessions at weekly intervals).

Venous ulcers were found to have the lowest response rate. In a rat model, Kuo et al. [8] were able to document enhanced wound healing by ESWT through increased tissue perfusion, suppression of the local inflammatory response, up-regulation of cell proliferation, especially of fibroblasts and keratinocytes, as well as neoangiogenesis from increased expression of VEGF (vascular endothelial growth factor) and eNOS (endothelial nitric oxide synthase). These effects are the result of membrane hyperpolarisation, activation of RAS (rat sarcoma protein, [9]) and increased release of growth hormones, above all TGF-β1 (transforming growth factor-β1) and VEGF [10, 11]. Moreover, Serizawa et al. [12] described that lymphangiogenesis occurred as a result of up-regulation of VEGF and bFGF (basic fibroblast growth factor). Animal experiments confirmed an improvement in a secondary lymphoedema after extracorporeal shock wave therapy [13]. ESWT has not shown to have any side effects so far.

In the patient discussed here, ESWT was found to lead to an impressive induction of granulation tissue formation and vascularisation. The leg ulcer recurrence can be attributed to the persistent ulcerogenic comorbidities, especially the lymphostasis. The increasing local obstruction in the normal flow of lymph, which was accompanied by the formation of cutaneous lymphatic fistulae, could be substantially improved through the use of ESWT. This corroborates the hypothesis of an induction of lymphangiogenesis by ESWT.

Conclusions for practice

- **Non-healing chronic wounds are still a challenging and sometimes frustrating medical problem causing substantial costs.**
- **By improving wound granulation and vascularisation, ESWT is an effective physical procedure for the treatment of non-healing acute and chronic wounds with minimal side effects.**

Abstract

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Abstract
Extracorporeal shock waves are defined as a sequence of acoustic pulses characterised by a fast pressure rise to over 100 MPa, followed by a decrease to normal pressure within a few microseconds. In the 1980s, extracorporeal shock wave lithotripsy (ESWL) was first used for the treatment of urolithiasis. Orthopaedists then began to use extracorporeal shock wave therapy (ESWT) to treat non-union fractures, tendinopathies and osteonecrosis. In dermatology, ESWT was first used in the treatment of chronic leg ulcers. Various studies conducted in the last 10 years have shown that ESWT stimulates angiogenesis, increases perfusion in ischaemic tissue, reduces the inflammatory response, enhances cell differentiation and is thus able to significantly improve wound healing. We used ESWT with great success to treat a non-healing chronic venous leg ulcer and also found that lymphatic drainage improved as a result of the ESWT procedure. This confirms that ESWT is an effective physical procedure for the treatment of therapy-resistant chronic wounds with minimal side effects.

Keywords
Chronic wounds · Physical therapy · Acoustic pulses · Wound healing · Treatment

Correspondence address

M. Stieger
Dermatology Clinic
Bern University Hospital (Inselspital)
Freiburgstr. 3
3010 Bern
Switzerland
marco.stieger@insel.ch

Conflict of interests. The corresponding author declares for himself and for his co-authors that there is no conflict of interests.

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