Tips

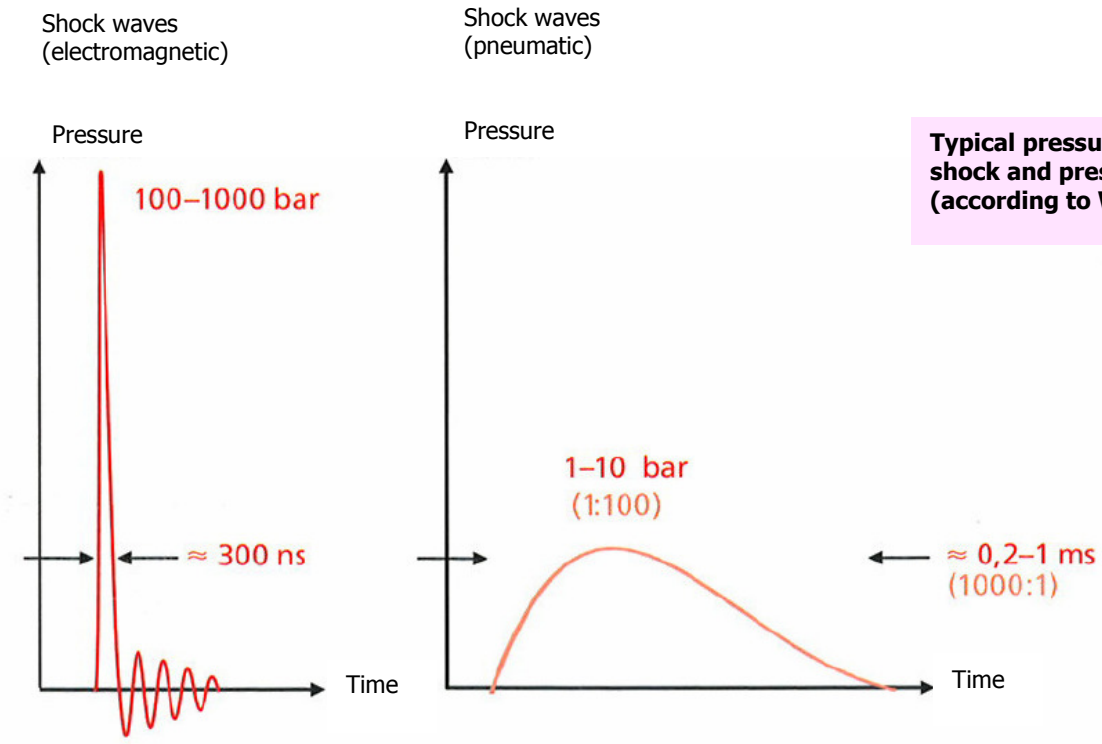
Shock waves with diabetic gangrene?

Background

Focused shock waves have been used to treat common orthopaedic indications (Dreisilker et al. 2007) such as tendinosis calcarea (Loew et al. 2007), humeral, radial and ulnar epicondylitis, heel spurs (Gollwitzer et al. 2007), pseudoarthrosis (Valchanou and Michailov 1991) and trigger points (Piontkowski and Sommer 2008) with great success for around 15 years. Extracorporeal Shockwave Therapy (ESWT) was originally developed for use in urology, where it has been used for the non-invasive fragmentation of kidney stones for around 30 years. These techniques found wider application with the introduction of radial pressure waves around ten years ago, which achieved comparably positive results in many indications.

Recently, extracorporeal (usually planar) shock waves have also started to be used in dermatology. Poorly healing wounds, such as leg ulcers, burns or diabetic leg ulcers, are today being treated with remarkable success (Schaden et al. 2007; Moretti et al. 2008).

A fundamental distinction is made between focused shock waves and radial pressure waves (Wess 2005). Shock waves are characterised by a very high pressure amplitude (around 1000 bar), very short pulse length in the range of around 300 ns, and extremely short pulse rise time of around 10 ns (see figure below).



Typical pressure profile for shock and pressure waves (according to Wess 2005).

Treatment using focused shock waves is known as ESWT (Extracorporeal Shockwave Therapy). Radial pressure waves are significantly slower (by a factor of 1000) and pulse amplitude is also usually no more than 10 to 100 bar. Despite this – probably as a result of the characteristic pulsatile, asymmetrical pressure profile – radial pressure waves exert a physiological effect similar to that of shock waves with many indications. Although they are not shock waves (Cleveland et al. 2007), this treatment is known as RSWT (radial shock wave therapy). The term EPAT (extracorporeal pulse activation therapy) appears to represent a more accurate description of this treatment and is now being used more and more frequently (Novak 2008).

Although the biological mechanism of action is not yet fully understood, shock wave therapy is being used successfully to improve blood supply and metabolic processes. This ultimately stimulates biological processes which lead to long-term healing.
The mechanisms of action which are known with certainty to give rise to the observed positive results before and during wound healing include the following effects:

Immediate increases in blood flow – particularly in the case of focused shock waves – which are caused not by a pulsed massage effect arising from vibration during pulse application, but through a demonstrable release of nitrogen monoxide (ENOS; endothelial nitric oxide synthesis) (Mariotto et al. 2005). This effects a biochemical vasodilation and is involved in producing other tissue factors through its role as a multifunctional messenger molecule.

An increase in cell wall permeability (Delius et al. 2002) and

a resultant general increase in metabolism.

The release of additional tissue factors, of which the most significant with regard to wound healing is VEGF (vessel endothelial growth factor), responsible for neovascularisation (Gutersohn et al. 2005).

A further key effect is the proliferation and differentiation of stem cells, which leads to the formation of new, healthy tissue with almost no scarring (Delhasse et al. 2008).

Case study
A 75 year old male patient with diabetic gangrene of both feet faced the prospect of imminent amputation. In addition to peripheral arterial occlusive disease (PAOD) and type II diabetes mellitus, the patient also suffered from arrhythmias with long-term oral anti-coagulation, cardiac insufficiency as a result of coronary heart disease, hyperuricaemia and arterial hypertension. Measureable PAOD, more advanced on the left than on the right side, and significant necrosis of the great toe were observed (on 20 April 2007). Using a visual analogue pain scale (0-10), the patient reported a pain score of between 7 and 9. Medication taken for pain consisted of pregabalin 75 mg 2 - 3 times in combination with Tramal® long 150 mg, Tramal solution and Novaminsulfon solution
Treatment commenced on 20 April 2007 (see figure, page 41). A combination approach with focused shock waves and radial pressure waves was used. Treatment was provided using the DUOLITH SD 1, a combination shock and pressure wave device (Storz Medical AG, Tägerwilen, Switzerland). Treatment was carried out diffusely through the balls of the feet, without direct contact with the necrotic tissue, initially using a combination of radial pressure waves (RSWT) and focused shock waves (ESWT).

Photograph from 20 April 2008 – start of therapy.

The second treatment was administered four days later, on 24 April 2007. Treatment parameters are shown in the table below.

Treatment parameters for each foot treated

Treatment date	Shock waves			Pressure waves		
	Impulses	Energy level (mJ/mm²)	Frequency	Impulses	Energy level (bar)	Frequency
20.04.2007	1000	0.07	4	1000	2.6	21
24.04.2007	1000	0.07	4	1000	2.6	21
Treatment suspended until 27.08.2007						
27.08.2007	1000	0.03	4			
10.09.2007	1000	0.03	4			
24.09.2007	1000	0.05	4			
8.10.2007	1000	0.05	4			
5.11.2007	1000	0.07	4			
19.11.2007	1000	0.07	4			
8.01.2008	1000	0.07	4			
22.01.2008	1000	0.07	4			
11.03.2008	1000	0.07	4			
25.03.2008	1000	0.07	4			
5.04.2008	1000	0.10	4			
19.05.2008	1000	0.10	4			
2.06.2008	1500	0.10	4			
24.06.2008	1500	0.10	4			
15.07.2008	1500	0.10	4			
29.07.2008	1500	0.10	4			

One week later the patient reported an inflammatory reaction above the necrotic areas. A prophylactic course of antibiotics was given and the treatment suspended by mutual consent. More pain medication was administered. One month later the patient reported that his pain had improved and that the necrotic areas of the feet had begun to heal.
By mutual consent, treatment was recommenced on 28 August. On this occasion, however, only focused shock waves were applied (0.03-0.10 mJ/mm² with a frequency of 4 Hz and 1,000 to 1,500 impulses per foot). Treatments were carried out at intervals of two to four weeks or longer. A total of 11 treatments were delivered in the period up to 11 March 2008. The patient felt – for the first time in many years – a pleasant sensation of warmth in the balls of his feet during shock wave application (see figure below from 11 March 2008). He also reported a significant reduction in pain.

Photograph from 11 March 2008 after eleven treatments.

The patient's pain medication was gradually reduced and then completely discontinued on 26 June 2008. On the visual analogue pain scale, the patient now reported a pain score of just 2. The shock wave treatment was then terminated. A follow-up was carried out on 18 November 2008. The patient required no pain medication in the intervening period.

Summary

This case study of a patient with diabetic foot gangrene illustrates the option of treating poorly healing wounds with shock waves. Two to four weeks appears to represent the ideal treatment interval. In the authors' opinion, the reason for the overreaction following the second treatment was the short interval between treatments of just four days. In this case, an interval of two to four weeks between treatments proved to be optimal.

English Translation of original article in German »Stoßwellen bei der diabetischen Gangrän?« in gefaessmedizin.net, 02/2009

Literatur

Cleveland R, Chitnis P, McClure S. Acoustic Field of a Ballistic Shock Wave Therapy Device. Ultrasound Med Biol 2007; 33: 1327–1335.

Delhasse Y, Neuland H, Steingen C. et all. Comparative study between the effects and mode of application of focussed and radial shock wave treatment on the behaviour of human mesenchymal stem cells (MSC). ISMST Congress, Juan les Pins, 2008.

Delius M, Ueberle F, Guo L. Anwendung von Stoßwellen für den Transfer von Molekülen in Zellen. Biomedizinische Technik 2002; 47: 382.

Dreisilker U, Wess O, Novak P. Extrakorporal erzeugte Stoß- und Druckwellen – eine wirksame Therapieform für die Geweberegeneration. Orthopädie-Report Spezial 2007; 147–151.

Gollwitzer H, Diehl P, Korff A, Rahlfs V, Gerdesmeyer L. Extracorporeal Shock Wave Therapy for Chronic Painful Heel Syndrome: A prospective, double blind, randomized trial assessing the efficacy of a new electromagnetic shock wave device. J Foot Ankle Surg 2007; 46 (5): 348–357.

Gutersohn A, Caspari G, Erbel R. Autoangiogenesis induced by cardiac shock wave therapy (CSWT) increases perfusion and exercise tolerance in endstage CAD patients with refractory angina. Circ J 2005; 69 (Suppl 1): 379.

Loew M, Juggowski W, Thomsen N. Die Wirkung extrakorporaler Stoßwellen auf die Tendinosis calcarea der Schulter. Der Urologe A 1995; 34: 49–53.

Mariotto SW, Cavalieri E, Amelio E, et al. Extracorporeal shock waves: from lithotripsy to anti-inflammatory action by NO production. Nitric Oxide 2005; 12: 89–96.

Moretti B, Notarnicola A, Aggio G, et al. ESWT-induced healing of diabetic foot ulcers. ISMST Congress, Juan les Pins, 2008.

Novak P. Extracorporal Pulse Activation Therapy (EPAT). ISMST Congress, Juan les Pins, 2008.

Piontkowski U, Sommer S. Combined EPAT/Focussed Shock Wave Therapy and Trigger Points in Sports medicine. ISMST Congress, Juan les Pins, 2008.

Schaden W, Thiele R, Kölpl C, Pusch M. et al. Shock wave therapy for acute and chronic soft tissue wounds: A Feasibility Study. J Surg Res 2007; 143: 1–12.

Valchanou VD, Michailov P. High energy shock waves in the treatment of delayed and nonunion of fractures. Int Orthop 1991; 15: 181–184.

Wess O. Physik und Technik der Stoß- und Druckwellentherapie. MOT 2005 (5): 7–32.