Shock wave over hand muscles: a neurophysiological study on peripheral conduction nerves in normal subjects

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Summary

Background and purpose: shock waves are defined as a sequence of single sonic pulses largely used in the treatment of bone and tendon diseases and recently on muscular hypertonia in stroke patients. Our purpose is to investigate the short and long term effect of extracorporeal shock wave therapy (ESWT) on the peripheral nerve conduction and central conductions from the treated muscles in normal human subjects in order to define safety criteria. Methods: we studied 10 patients normal subjects. Motor and sensory nerve conduction velocity and F response from right ipothenar eminence (abductor digiti minimi) of the hand was recorded. Furthermore MEP latency and amplitude and central conduction from the same muscles by transcranial magnetic stimulation was evaluated. In all subjects each neurophysiological measures were monitored before, immediately after, 15 minutes and after 30 minutes from the active ESWT treatment (1600 shots with an energy applied of 0.030 mj/mm^2). Results: no significant short or long term changes were noted in sensory and motor peripheral nerve conduction and in central motor conduction in all the subjects evaluated after ESWT. Conclusions: the ESWT has no effect on sensory and motor peripheral nerve conduction and in central motor conduction. The ESWT using low level of energy represent a safety method for treating the muscles in human subjects without involvement of motor or sensory nervous trunks. Different mechanisms of action of ESWT are discussed.

Key words: tms, spasticity, peripheral nerve, extracorporeal shock wave, ESWT, muscles.

Introduction

Shock waves are defined as a sequence of single sonic pulses characterised by high peak pressure (100 mPa), fast pressure rise (<10 ns) and short duration (10 μs). Different studies and clinical experiments have demonstrated the efficacy of shock waves in the treatment of bone and tendon diseases, including pseudoarthrosis[1-3,6-8] tendinitis calcarea of the shoulder[4,5,9,10], epicondylitis[6,11], plantar fascitis[7,12], and several tendon diseases[27], especially in athletes[8,9,13,14]. In our previous study we described the reduction in spasticity in patients affected by stroke after shock wave therapy [15,16] and we suggested a possible use of shock wave treatment on patients suffering from muscular hypertonia after lesion of central nervous system. In the previous study we have monitored the effect of the Shock waves using low level of energy (0.30 mj/mm^2) on the peripheral nerve conduction and muscle activity in stroke patients without significant effect on the nervous peripheral structures. Despite the large use of shock wave therapy no information exist on the effect of the shock wave on the peripheral structures in humans.
The aim of this experimental study is to investigate the short and long term effect of shock wave on motor and sensory peripheral conduction and on motor central conduction in the treated muscles studied by electroneurography and transcranial magnetic stimulation in normal human subjects.

Subject and methods

Ten normal subjects, were enrolled in the study. The subjects (five men and five women) had a mean age of 30 years (26-45 years).
No subjects took medications which could have an impact on the study (e.g. gabaergic medications). No other treatment were performed. All subjects provided informed consent.

Study procedure

The study was an open study in which each patient served as their own control.
In each subject, the neurophysiological measures were performed before, immediately after, after 15 minutes and 30 minutes from the active shock wave treatment. Long monitoring of the neurophysiological measures (after 15 and 30 minutes) was performed in order to investigate possible long lasting effect of the ESWT.

All subjects were seated in an armchair with their elbows semiflexed; the forearm was pronated, fully relaxed and supported by the arm of the chair.

Distal motor action potentials (MAP), motor nerve conduction velocity and F responses were recorded from right abductor digiti minimi (ADM) using surface electrodes by ulnar nerve stimulation. F wave responses were elicited by supramaximal stimulation of the ulnar nerve once a second. Ten F wave responses were collected at each recording session. For each set of 10 stimuli we measured the mean F wave peak-to-peak amplitude and the mean latency of the responses[11]. Sensory action potentials (SAP) for the V finger were recorded using ring electrodes and stimulating the ulnar nerve at wrist.

Motor evoked potentials (MEPs) were recorded from the right abductor digiti minimi muscles. The amplified and bandpass filtered (50 Hz to 20 KHz) EMG signal was fed into a Basis Esaote Machine (Esaote Company, Florence, Italy) with a sampling rate of 5000 Hz. An auditory feedback EMG signal was given to ensure complete voluntary relaxation of the target muscles. Trials in which voluntary EMG activity occurred were discarded from further analysis.

TMS was applied through a round magnetic coil (outer diameter 14 cm, maximum magnetic field 2.5 Tesla) using a Magstim 200 magnetic stimulator (The Magstim Company, Whitland, Dyfed, U.K.). The focal coil was positioned flat over the skull on the hemisphere examined on the optimal scalp position ("hot spot") defined as the site where the lowest stimulator output intensity consistently yielded the largest amplitude and the minimal latency MEPs. Constant position of the coil relative to the skull, throughout the session, was ensured by a scalp cup, where the site of stimulation was marked.

Different TMS parameters were used to investigate motor system excitability.

The "motor threshold" (MT) intensity was defined as the lowest stimulator output intensity capable of inducing MEPs of at least 50 μV peak-to-peak amplitude in the TE muscles in at least half of 10 trials. Throughout, stimulus intensities were expressed as a percentage of the maximum stimulator output. The motor threshold (MT) was determined in relaxed ADM muscles.

Peak-to-peak MEP amplitudes were measured in the resting at a stimulus intensity of 130% of the resting motor threshold. A total of 7 stimuli were delivered to each muscle in each session peripheral stimulation of the median nerve. The cortical MEP amplitude is related to the number of corticospinal neurons activated at a given stimulus intensity. Peripheral MEP was recorded from the same ADM muscles stimulating the level C7 at cervical site. The difference in latency between cortical and peripheral MEP allows the study of central conduction time.

Clinical and electrophysiological values of each patient were submitted to analyses of variance (ANOVAs) with repeated measures. Post-hoc comparisons were performed with paired t-tests adjusted with the Bonferroni method. The alpha level chosen for all analyses was 0.05.

Shock wave Therapy Instrumentation

An electromagnetic coil lithotriptor (Modulith SLK® by Storz Medical AG) provided with in-line ultrasound, radiographic and computerized aiming (Lithotrack® system) was used. The pressure pulses were focused in the abductor digiti minimi muscle, using 1600 shots by an ultrasound pointer-guide. The energy applied was 0.030 mJ/mm^2. Because low energy is used, the therapy is painless and does not require any kind of anaesthesia or the use of analgesic drugs.

Results

No significant changes were in latency and amplitude of motor action potential and sensory action potential in peripheral nerve conduction study after ESWT (Tab. 1). No significant changes were noted in latency and amplitude of late responses (F waves) across the different recordings after ESWT (Tab. 1).

No significant changes were noted and in motor threshold and in latency and amplitude of cortical motor evoked potential by transcranial magnetic stimulation after EWST. No changes were in noted in central and peripheral motor conduction by transcranial magnetic stimulation after EWST (Tab. 1).

Discussion

The main finding of this study is that a single active treatment of shock wave therapy do no affect peripheral nerve conduction or central motor conduction from the treated muscles. This finding represents an additional information on the safety of the shock wave therapy on the human muscles. The large use of shock wave therapy is mainly in the treatment of bone and tendon diseases[1-9], and the possible involvement of peripheral nerve could be secondary. However there is no standardized guidelines for the use of ESWT in soft tissue conditions. The possible future application of this treatment over the muscles in human suggests further investigation over the possible effect on peripheral and central nervous system.

In our previous study the reduction in spasticity in muscles of paretic hand of patients affected by stroke and in patients with cerebral palsy, after one session of shock wave therapy was important and long lasting[15, 16].

Some studies have reported that single and repeated application of ESWT induces denervation of free nerve endings in animal models[11, 17]. The authors suggest that this denervation can explain the antinociceptive effect.

Different studies have investigated the mechanisms of the shock waves, which can induce enzymatic[18] and non-enzymatic nitric oxide (NO) synthesis[19, 20]. Nitric oxide is involved in neuromuscular junc formation in peripheral nervous system[21] and in important physiological functions of the CNS; including neurotransmission, memory and synaptic plasticity[22]. NO synthesis has been suggested to be one of the most important mechanisms to explain the effectiveness of shock waves in the antiinfiammatory treatment of different tendon diseases[19, 20].

A direct effect of shock waves on fibrosis and on the reologic components of the chronic hypertonic muscles should be considered in agreement with the documented therapeutic effect on bone and tendon diseases[6-10, 24].

	BASELINE	AFTER EWST	AFTER 15 MIN	AFTER 30 MIN	
LATENCY MAP (ms)	3.5 (1.3)	3.6 (2)	3.9 (1.7)	3.6 (1.4)	NS
AMPLITUDE MAP (mV)	12,35 (3,9)	12,29 (3,4)	11,57 (2)	11,35 (3,9)	NS
PERIPHERAL MOTOR NERVE CONDUCTION (ms)	55,45 (5)	54,86 (4,8)	55,59 (4,1)	54,91 (4,3)	NS
SAP LATENCY (ms)	2,05 (0,2)	2,13 (0,2)	2,16 (0,1)	2,18 (0,2)	NS
SAP AMPLITUDE (μV)	31,6 (7,8)	33,6 (9,0)	29,9 (8,4)	27,3 (5,9)	NS
F WAVE MEAN LATENCY (ms)	25,71 (1,89)	26,15 (1,96)	25,90 (1,63)	25,98 (1,94)	NS
F WAVE MEAN AMPLITUDE (uV)	700 (100)	790 (120)	650 (200)	670 (140)	NS
MOTOR THRESHOLD (TMS) (%)	50 (8)	55 (8)	50 (7)	50 (7)	NS
MEP (TMS) LATENCY (ms)	21,92 (1,5)	22,45 (1,5)	22,65 (1,4)	22,66 (1)	NS
MEP (TMS) AMPLITUDE (mV)	12 (6)	12 (4)	12 (6)	12 (7)	NS
CENTRAL CONDUCTION TIME (ms)	7 (2)	7(1)	7 (2)	7 (3)	NS

Table 1. Electrophysiological findings after ESWT in normal subjects. Values are in mean and standard deviations.

The effect of mechanical stimuli of shock waves on the muscle fibres next to the tendon cannot be excluded[24]. Continuous or intermittent tendon pressure can decrease the spinal excitability without long lasting clinical and neurophysiological effect[23]. Nevertheless because no changes in motor conduction and in MEP elicited by TMS was noted in the treated muscles we can exclude any kind of long lasting effect on motor excitability by ESWT. No changes were observed in amplitude and latency of distal motor and sensory action potential and of late responses, excluding a significant effect of shock wave therapy on peripheral nerves and spinal excitability.

Shock wave therapy at low level of energy therefore appeared to be safe, non invasive and without complications for motor and sensory peripheral nerve and central conduction. This therapy could open a new field of research in the treatment of peripheral muscles diseases without involvement of peripheral nerve conduction.

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