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# Prospects for Development of Shock Wave Therapy

**B.A. Garilevich**
*Central Clinical Air Force Hospital, Russia*

**Y.V. Kudryavtsev**
*Central Clinical Air Force Hospital, Russia*

**Y.V. Olefir**
*Central Clinical Air Force Hospital, Russia*

**Y.V. Andrianov**
*Central Clinical Air Force Hospital, Russia*

**A.E. Rotov**
*Central Clinical Air Force Hospital, Russia*

## INTRODUCTION

Nowadays the world medical practice widely uses the method of extracorporeal shock wave lithotripsy for treatment of patients with urolithiasis bay means of pulverizing action of focused shock waves (FSW). In the early 1980s in Germany, the Dornier Medical Systems Company fabricated the first lithotriptor based on the electrohydraulic principle of shock wave generation. By 1988, practically all countries had applied lithotriptors developed by Dornier Medical Systems. Later, more than 15 countries started to fabricate their own lithotriptors, which use various methods of FSW generation, such as electrohydraulic, electromagnetic, and piezoelectric. These countries were Germany, USA, Russia, China, Italy, France, Israel, Turkey, Slovakia, Poland, Austria, Sweden, and so forth.

However, the given method of the physical effects can be used not only for the extracorporeal fragmentation of calculi. The biological effects of shock waves presume a perspective of their use for treatment and aftertreatment of the patients with other disorders and pathological conditions using their stimulatory and inhibitory actions.

## BACKGROUND

The method of shock wave therapy (SWT) originates in the late 1980s and in the early 1990s. A number of investigations have proved that the influence of shock waves accelerates callus formation and fracture healing, faster healing of skin wounds, as well as intensifies the regenerative and reparative processes and stimulated metabolism in tissues and cells (Garilevich, Kudryavzev, & Dzeranov, 2003; Garilevich, Zakharov, Kudryavzev, & Kirpatovsky, 1997; Haupt, 1997; Valchanov & Michailov; Zubkov, Garilevich, & Olefir, 2005).

In 1988, SWT was for the first time successfully applied for treatment of fractures (Valchanov & Michailov). Thereafter, the method has been widely used in orthopedic and traumatic surgery and sports medicine. With accumulation of experience, the scope of application of this method has been gradually extended. So, its efficiency in treating Peyronie's disease, neuromuscular dysfunction in children with spastic cerebral paralysis (Siebert & Bush, 1997) has been proved. The investigations of the last years have exposed a perspective of cardiologic use of SWT at patients with ischemic heart disease (Nishida et al., 2004). The basic clinical effects of shock waves are: analgesic action, activation of microcirculation and neonangiogenesis, stimulation of the metabolic processes, resorption of healing connective tissue, anti-inflammatory, and antibacterial action (Garilevich, Kudryavzev et al., 2003; Garilevich, Zakharov et al., 1997; Gerdesmeyer et al., 2005; Haupt, 1997; Kudryavzev, Garilevich, Kirpatovsky, & Olefir, 2003; Mironov, Vasiljev, & Burmakova, 1999; Nishida et al., 2004; Zubkov, Garilevich, & Olefir, (2005).

Nowadays, there are a number of issues about the use of the inhibitory action of shock waves. The methods of cancer treatment through the influence upon them by ultrasonic waves of high intensity (U.S. Patent No. 3735755, 1975; U.S. Patent No. 4441486, 1986), and focused shock waves (W.O. Patent No. 86/05104, 1986) are well known. The cytotoxic action of shock waves upon cancer cells (Eisenberger & Miller, 1999; Kohri et al., 1990; Mastikhin, Nicolin, Teslenko et al., 1995) has been also described. The ability of FSW, besides the mechanical damage of cells, to break sulfide bonds and to form highly reactive free radicals makes possible the participation of the free radical mechanism in changing the membrane permeability of cells (Mastikhin et al., 1995).

However, these methods have a restricted application due to a high negative pressure of a shock wave impulse (SWI) provokes cavitation processes in the field of the diffusion of a wave beam that also damages healthy tissues and causes a decrease in the efficiency of tumor growth suppress.

Disadvantages of the known methods have been eliminated in the new offered method of treating malignant neoplasms based on a synchronous influence of SWI and pulsed electrical field of nano or microsecond range of duration (Andriyanov et al., 1999).

Nowadays, various firms produce equipment to be used for the treatment of patients with orthopedic disorders applying FSW. Disadvantages of the given equipment result from the fact that the parameters of SWI do not differ from those applied to the extracorporeal fragmentation of urinary calculi. That is to say, the focus of shock waves uses the pulverizing action of FSW, which is unacceptable for therapeutic influence upon internal body organs. Another disadvantage of the available equipment for SWT is that the diameter of the focus of a shock wave varies from 3 up to 12 mm that does not meet the size of the area of damage or pathological process and particularly organs' pathology. Thus, the available equipment does not essentially differ from lithotriptors, which are destined for extracorporeal lithotripsy, and hence, there is no essential difference either in cost or in maintenance charges.

## NEW OPPORTUNITIES FOR THE METHOD OF SHOCK WAVE THERAPY

Experimental investigations in studying the biological action of shock waves upon organs and tissues have allowed establishing parameters of their stimulatory influence acting upon cell metabolism and reparative processes that has led to the development of a pilot sample of the shock wave device "Biostim" (Andriyanov, Yu.V., Garilevich, B.A., Cokhan, V.E., & Kudryavzev, Yu.V., 2000). Besides, the development of the lithotripter "Urat-P2" (Russia) has introduced modes of operation of the shock waves generator, which also have positive therapeutic effects. These devices use an electrohydraulic system for shock wave generation.

The first stage of the examination with regard to determining the parameters of stimulatory influence of shock waves has included experiments on animals. The influence of shock waves has been experimented upon the kidney at simulating acute and chronic pyelonephritis and wound surface.

The examination has found out that therapeutic action upon metabolic processes in tissues produces microsecond SWI varying from 3 up to 20 MPa in amplitude, and from $15^0$ up to $60^0$ in angulation of SWI front towards the time axis with a pulse duration at a half-height its amplitude varying from 0.6 up to 2.0 μsec. These processes are effective with pulse compression amplitude (i.e., positive phase of the pulse) less than 20 MPa and pulsing more than 500 pulses.

Experiments with a provoked skin wound have shown that the shock wave stimulation (SWS) made the wounds heal 5 to 7 days earlier than in the control group. Histological analysis of the healed wound has found out that the epidermis has been correctly formed having a normal position of the cell layers and well expressed dermal papillae. The control group of animals has shown a large area of the expansion of dense fibrous connective tissue, both in derma and in subcutaneous fatty tissues, as well as smaller integrity of smooth muscle fibers of derma.

Histological analysis of the kidney tissue after SWS has shown changes with evidence of metabolic processes activation. There has been present hyperemia of microcirculation blood vessels of the cortical and

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