Extracorporeal Shock Wave Therapy in Orthopaedics

ESSAY

Submitted in fulfillment for Master Degree

In
ORTHOPAEDICS

BY

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2008

Abstract

The exact impact that shock wave impart to different musculoskeletal tissues is not understood completely. Relative to stone disintegration, the shock wave presumably cause high stress forces on the stone surface by the high pressure amplitude and the short rise time, thus exceeding the elastic strength of the stone and disintegrating its surface.

The value of shock wave treatment was proven in the treatment of patients with fracture nonunions with a 60% success rate and there was a positive effect in patients with tennis elbow, painful heel, and calcifying tendinitis of the shoulder.

Keyword: shockwave, high stress, disintegration and cavitations

ACKNOWLEDGMENT

This essay has been accomplished under the supervision of Dr. Ibrahim Elgaidy professor of orthopaedic surgery, faculty of medicine, Cairo University, and Dr. Ahmed Galal Elsaid lecturer of orthopaedic surgery, faculty of medicine, Cairo University. I am deeply grateful for their continuous support, valuable remarks, and enlightening criticism.

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Introduction

The shock wave is a transient pressure disturbance that propagates in three-dimensional space with a sudden rise from ambient pressure to its maximum pressure at the wave front.

The exact impact that shock wave impart to different musculoskeletal tissues is not understood completely. Relative to stone disintegration, the shock wave presumably cause high stress forces on the stone surface by the high pressure amplitude and the short rise time, thus exceeding the elastic strength of the stone and disintegrating its surface.

Application in fracture was chosen based on observations obtained during animal lithotripsy studies of the biologic tissue effects of shock wave, namely that shock wave striking the pelvis elicited a significant osteogenic response. **(Ekkernkamp et al, 1992)**

For the past 10 years this technology has been increasingly applied to a broad range of musculoskeletal conditions. These applications include calcific tendinitis of the shoulder, nonunion, and delayed union of fractures. **(Delius, 1997)**

These applications initially stemmed from the concept of disintegrating calcifications in the shoulder that were similar to lithotriptic renal stone disintegration. **(Thiele et al, 1997)**

However, the value of shock wave treatment was proven in the treatment of patients with fracture nonunions with a 75% success rate and there was a positive effect in patients with tennis elbow, painful heel, and calcifying tendinitis of the shoulder. **(Trebinjac et al, 2005)**

Advantages of extracorporeal shock wave therapy are avoidance of surgery, safety, and effectiveness. Compared with open surgery, the costs of extracorporeal shock wave therapy are reasonable.

In this essay, the principles and applications of extracorporeal shock wave therapy are reviewed, followed by a detailed survey on the indications, technique, results and complications of shock wave therapy in orthopaedics.

Chapter 1

Principles of Shock Wave Therapy

Shock wave originally was applied clinically as lithotripsy to break up and disrupt calcific deposits within the body, specifically stones within the renal, biliary, and salivary gland tracts. Extracorporeal shock wave therapy now has become established as the procedure of choice for most renal calculi. It represents a noninvasive and very effective technique for treating as many as 98% of renal calculi. For the past 10 years this technology has been increasingly applied to a broad range of musculoskeletal conditions. **(Delius, 1997)**

These applications include calcific tendinitis of the shoulder, nonunion, and delayed union of fractures**. (Schleberger et al, 1997)**

These applications initially stemmed from the concept of disintegrating calcifications in the shoulder that were similar to lithotriptic renal stone disintegration**. (Thiele et al,1997)**

The fracture application was chosen based on observations obtained during animal lithotripsy studies of the biologic tissue effects of shock wave, namely that shock wave striking the pelvis elicited a significant osteogenic response. **(Ekkernkamp et al, 1992)**

Basic Physics:

The steepening of a sound wave is caused by the pressure dependency of the wave propagation. The velocity of the sound wave increases with increasing pressure. Therefore, wavelets at high pressure move faster than the wavelets at lower pressure, which leads to a deformation of the wave.

For very high sound intensities, the wave crest assumes a saw tooth appearance. With increasing amplitude, it subsequently becomes a shock wave. A clinically applicable shock wave represents nothing more than a controlled explosion producing a sonic pulse. **(Ogden et al, 2001)**

When the shock wave enters the tissue it may be dissipated and reflected so that the kinetic energy is absorbed according to the integral structure of the tissues or structures that are exposed to the shock wave.

The transmitted force depends on the physical properties of the material in question; for example, the forces are different for air as compared with a liquid such as water. The shock wave is a transient pressure disturbance that propagates in three-dimensional space with a sudden rise from ambient pressure to its maximum pressure at the wave front. Medically useful shock wave usually is generated through a fluid medium (water) and a coupling gel to facilitate transmission into biologic tissues. **(Cheing et al, 2003)**

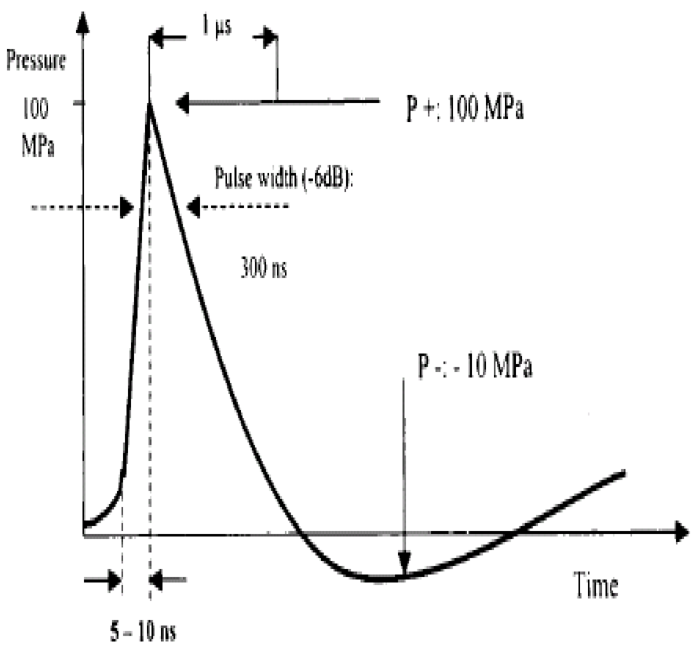

Fig 1. The typical form of a therapeutic shock wave is shown. There is a very rapid positive rise in pressure over nanoseconds to approximately 10 MPa, which eventually is followed by a variable negative pressure, which may affect cavitation. The extra wave lasts several microseconds.

Figure 1

(Schleberger et al, 1997)

The basic physical properties of a shock wave causes expansion and concentration within a medium, and thereby change the local density. Wave propagation may be described as an alternating compression and relaxation of the medium along the direction of propagation.
(Schulthei et al, 1996)

At the boundary layer between two media one part of an approaching shock wave will be reflected and the other part will be transmitted. Losses through attenuation depend on the medium through which they are transmitted. In air, the attenuation is very high. In water, however, losses through attenuation are approximately 1000 times lower than an air. **(Hausdorf et al, 2004)**

A shock wave is a sonic pulse that has certain physical characteristics. There is a high peak pressure, sometimes more than 100 MPa (500 bar), but more often approximately 50 to 80 MPa, a fast initial rise in pressure during a period of less than 10 ns, a low tensile amplitude (up to 10 MPa), a short life cycle of approximately 10 μs, and a broad frequency spectrum, typically in the range of 16 Hz to 20 MHz.
(Figure 1) **(Schleberger et al, 1997)**

For shock wave to be effective in the clinical situation, the maximally beneficial pulse energy must be focused (concentrated) at the point at which treatment is to be provided. There are two basic effects:

The direct generation of mechanical forces (primary effect), and the indirect generation of mechanical forces by cavitation (secondary effect). **(Maier et al, 2003)**

Methods of Shock Wave Generation:

There are three main techniques through which shock wave may be generated. These are the electrohydraulic, electromagnetic, and piezoelectric principles, each of which represents a different technique of generating the shock wave. All of these techniques of shock wave production depend on the conversion of electrical energy to mechanical energy. (Figure 2)

The basic concept of each device is similar, and is based on the principle that the acoustic impedances within the human body are very similar to those of water. (Table 1)

Accordingly, the shock wave are generated within water and subsequently transferred to the human body by means of an appropriate contact medium. This ensures small losses attributable to attenuation and reflection by any boundary areas. The energy of the shock wave will be concentrated in the treatment focus**. (Hausdorf et al, 2004)**