EFFICIENCY OF ESWL IN LOWER CALICEAL STONES

THESIS

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BY

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بسم الله الرحمن الرحيم

CONTENTS

INTRODUCTION

In modern medicine there has been new developments that complement or supplement the purely surgical techniques. Particularly in urology; this trend has taken on a special significance in the last years.

In connection with the search for new technology; the use of shock wave was a potential mean of realizing the goal of contactless treatment of renal calculi.

ESWL has been in clinical use for more than twelve years within a short time, extensive statistics have documented its efficiency in the treatment of most renal and ureteral calculi.

However, the results of ESWL in treatment of lower caliceal calculi are still debatable because of poor drainage of the lower calix.

REVIEW OF LITERATURE

CHAPTER 1

MACHINE AND ITS GENERATIONS

Historical development of ESWL

Introduction

ESWL has rapidly revolutionized the management of upper urinary tract calculi.

Coupled with valuable auxilliary techniques such as : percutaneous nephrolithotripsy (PCNL) and ureteroscopy, ESWL has reduced the necessity of operative stone removal to less than 10% of cases in which the stones would previously have been removed surgically, (Webb et al., 1985).

To date, more than 800 centers have been established worldwide where more than 2,000,000 patients have been successfully treated, Eisenberger et al., 1991).

Historical background of ESWL

Eisenberger 1991 has summerized the development of ESWL as follows:

The first physical classification of electromagnetically induced, unfocused shock waves was performed by Eisenmerger in 1959. In 1966, the transmission of shock waves through human body was firstly observed by a test engineer at Dornier system, when he touched a target body at the very moment of impact of a high velocity projectile and fell a kind of electrical shock, although no evidence of electrical phenomena was noted. The first animal experiments to study the effect of focused shock waves on biological tissue were performed in 1969 by Dornier system.

In 1971, the first in vitro disintegration of kidney stones by shock waves was advised by Haussler with the Dornier system shock wave gun. In the initial test phase, the generation of only four shock waves took an entire day and produced only a network of cracks in a kidney stone.

From 1972 to 1974, laboratory tests on the disintegration of kidney stones by focused shock waves were carried out. These experiments were subjected to the following criteria:

-reproducible generation of shock waves.

-adequate focusing of shock wave energy.

-acoustic coupling to guarantee energy transfer.

-localization of the stone.

-determination of optimal stone-disintegration energy.

In vitro and in vivo studies on the action of focused shock waves on biological tissue followed from 1974 to 1978. The clinical application of ESWL was demonstrated on a canine kidney stone model. These in vitro and in vivo experiments from 1972 to 1978 were performed by Eisenberger.

Chaussy,Schmiedt and Brendel.

On February 7, 1980, the first patient suffering from a kidney stone was successfully treated with ESWL at the Department of Urology of the University of Munich.

Two years later, the first ESWL center was inaugurated at the Grosshaden Urologic clinic of Munich University. This was followed by the installation of the second center in 1983 at the Urologic clinic of the katharinen Hospital in Stuttgart. The first series model (Dornier HM_3) was installed there.

ESWL for biliary calculi:

From 1980 to 1982, in vitro and vivo studies were carried out on the application of ESWL to human gall stones. These studies were performed on the Department of Gostroenterology at Munich University by: Sauerbruch, Delius, Brendel and Paumgartner.

In 1985, a patient suffering from a gall stone was the first to be treated with a modified Dornier HM_3 lithotriptor. The treatment concept of biliary ESWL, however, induced oral chemolysis. To date, more than 10,000 patients have been treated in Germany.

From 1985 to 1990, more than 20 different second and third generation lithotriptors have been developed and introduced for clinical application. These devices employ different principles of shock wave generation, focusing, acoustic coupling and stone localization. In general, the lithotriptors became smaller, cheaper, multifunctional or a combination thereof.

The Physics Of Shock Waves

Physical background

The application of extracorporeally induced shock waves for disintegration of human urinary stones is derived from results of basic research in the fields of acoustic physics. Investigations into the causes of pitting often seen on space crafts and on super sonic aircrafts after high-speed flights revealed that pitting was caused by shock waves generated upon collision of the craft with micrometeorites or raindrops. The physical principle that explains the destructive potential of the shock waves is the build-up of energy when shock waves hit solids of different acoustical behaviour. (Chaussy et al., 1981).

Physical Properties of shock waves

Shock waves are high energy amplitude of pressure generated in water or air by a sudden release of energy in a small space (Atala et al., 1989).

The basic technical principles of shock waves are often confused with those of ultrasound waves. Although both shock waves and ultrasonic waves are governed by the same laws of acoustics, they are fundamentally different when compared in terms of their basic contents. Unlike ultrasound, which consists of a sinusoidal wave of a defined wavelength with alternating positive and negative deflections, a shock wave consists of a single positive pressure front of multiple frequencies with a steep onset and gradual decline. Shock waves undergo substantially lower attenuation than ultrasound waves when propagating through water or body tissues. Thus, they can be transmitted through water and into the body without major loss of energy and with no damage to tissue. (Chausy et al., 1987).

The principle of stone disintegration

Acoustic impedance is a characterstic of any medium and is equal to the product of density and sound velocity. Due to similar acoustic impedances of water and tissue shock waves travel through the body with minimal reflection and refraction. In contrast to this, the acoustic impedance of urinary calculi is 5 to 10 times higher than that of tissue. Eisenberger et al., 1991).

Once the focused shock waves reaches the stone the following effects occur: the pressure front is partially reflected at the front surface of the stone and thus is split into compressive and tensile components leading to the build up of a high pressure gradient. Eventually the comprehensive strength of the stone material in the particular region is exceeded causing disintegration at the front surface and tears throughout the entire stone [figure 1a & b].

A portion of the wave continues through the stone and is reflected at the rear surface, where the same effect takesplace, leading to further destruction of the stone material. [figure 1c & d]. During this process more and more additional surfaces are created in the middle of the stone as the stone components break. There the shock waves are again reflected and the material breaks into more and more fragments as the comprehensive strength is exceeded. After repeated exposures this process finally results in complete disintegration of all stone parts (Chaussy 1987).

Cavitation

Beside the direct disintegrative effect of shock waves, stone fragmentation may occur secondarily due to the phenomenon of cavitation around the stone. Cavitation is produced by negative pressure that immediately follows the shock wave front. On the other hand, negative pressure may be produced by reflection of the shock wave front at interface when a compressive pressure pulse changes its action and becomes a tensile pulse. If tensile forces are strong enough, they may locally exceed the strength of a medium. This causes cavitation in liquid (Water, blood, urine, bile), where the liquid is pulled apart to creat a small bubble. These bubbles form around nuclei, such as duct particles and stone crystals. and collapse immediately once the shock front has passed [figure 2]. This collaps leads to high pressure locally that may produce secondary shock waves, microscopic high speed jets within the liquid high temperature and even illumination. Such collapsing cavitation bubbles found around the stone may cause erosive surface damage comparable to the cavitation induced damage of high speed propellors or racing boats. Eisenberger et al., 1991).

Components Of Lithotiptor

Shock wave lithotriptors must carry out four steps in order to destroy calculi satisfactorily:

1- Generation of high energy shock wave.

2- Accurate focusing of that shock wave on the specific target.

3- Coupling of the shock wave from its point of generation to its point of impact with minimal attenuation.

4- Accurate positioning of the target directly over the focus of the wave.

Equipments and Techniques

The Dornier Human Model 3 (HM_3) lithotriptor developed and manufactured by Dornier of West Germany is by far the most widely used equipment for ESWL.

The major features of this machine are the water tub with integrated ellipsoid and spark electrode, biplane x-ray system, and the patient support. (Chaussy et al., 1980). The treatment is carried out in three steps:

1- Positioning
2- Stone localization
3- Shock wave application

1- Positioning

Positioning involves adapting the stretcher to the stone-bearing side and patient size. Patients with concrements close to the spine should be turned by simultaneously lowering the stone-bearing side. The patient is fixated with straps in order to balance the body's bouyancy in water Eisenberger et al., 1991).

For the treatment of distal ureteral calculi, the shock wave can be applied via the gluteal region or perineally. Recently, a prone position of the patient can be used for the