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Non contrast computed tomography stone parameters as a predictor of stone disintegration by shock wave lithotripsy for upper urinary tract stones

THESIS

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Non Contrast Computed Tomography Stone Parameters as a Predictor of Stone Disintegration by SWL for Upper Tract Stones

Abstract

Objective: To assess the value of noncontrast computed tomography(NCCT) as a possible predictor of renal stone disintegration by shockwave lithotripsy (SWL).

Patients and methods: The study included 50 consecutive patients (46 males, 4 females; mean age: 36 yr) with a solitary renal stone of 0.5–2.0 cm in length. NCCT was performed using a multidetector row CT scanner at 120 KV and 240 mA. A bone windowwas used to measure stone attenuation values. SWL was performedwith an electrohydrulic lithotripter. Failure of disintegration wasdefined as no fragmentation of the stone after three sessions. The impactof patients' body mass index (BMI) and the stones' location, size, mean attenuation value, and the skin-to-stonedistance on disintegration were evaluated by univariate and multivariateanalyses.

Results: Failure of disintegration was observed in 5 patients (10%). BMI, stone size, and stone density >26.7, 14.7mm, 1031HU respectively were significant predictors of failure.

The success rate of extracorporealSWL at 3 mo was 90% (46 of 50 patients); 39 patients werestone free and 6 had residual fragments <4 mm.

Conclusions: Obesity, increased stone size, and increased stone density as detected by NCCTare significant predictors of failure to fragment renal stones by SWL. Analternative treatment should be advised for obese patients with stonedensity >1031 HU, BMI >26.7, and stone size>14.9mm.

KEYWORDS:

Shock wave lithotripsy

Renal calculi

Stone size

Stone density

Skin to stone distance

Body mass index

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Abbreviations

BMI	Body mass index
C.I.R.F.	Clinically Insignificant Residual Fragments
C.O.M.	Calcium Oxalate Monohydrate
C.T.	Computed Tomography
SSD	Skin to stone distance
S.W.L	Extra Corporeal Shock waves lithotripsy
H.M.	Human Model
H.U.	Hounsfield Unit
I.V.U.	Intra Venous Urography
K.U.B.	Kidney Ureter Bladder
M.R.I.	Magnetic Resonance Imaging
N.C.C.T.	Non Contrast Computed Tomography
P.C.N.	Per Coetaneous Nephrostomy
S.D.	Standard Deviation
S.WS.	Shock Waves.
U.H.C.T.	Un-enhanced Helical Computed Tomography
U.S.	Ultrasound

Aim of the work

Our aim of this prospective study is to assess the value of using non contrast computed tomography (NCCT) stone parameters (stone density, skin to stone distance, stone size) and BMI. As a possible predictor of renal stone disintegration by shock wave lithotripsy (SWL), Aiming for better selection of patients who may get benefit from this modality of treatment, decreasing chances of unnecessary renal damage and cost.

INTRODUCTION

Since the introduction of SWL by Chaussy in 1980,the therapeutic strategy for urolithiasis has completely changed.Dr. Christainchaussy of the University of Munich was the first to pulverize renal stone in humans using a new concept termed extracorporeal shock wave lithotripsy. Using this technology, he determined that patients could have renal or ureteral stones removed without the need of an incision or skin puncture. Due to its noninvasiveness, the concept quickly gained widespread and became the treatment of choice for the vast majority, of urinary stones. The first lithotripter model (Dornier hm-1) was soon replaced by the HM-2 in 1982, and the HM-3in 1984.The HM-3 was first used in the United States on February 23, 1984 at MethodistHospital in Indianapolis***(Tiede et al., 2003).***

shock wave lithotripsy technology has evolved significantly in the last two decades. Initially, the technical improvement in the lithotripters was made based on empirical experience to provide user convenience and device multfunctionality. Recently, a significant progress in the basic research of SWL has stone comminution and tissue injury,it is now recognized that stone comminution is a multifaceted progressive process involves synergistic of two fundamental mechanisms namely, stress wave induced dynamic fracture and cavitation erosion ***(Zhu et al., 2002a)***. In addition, tow mechanisms have been proposed to be responsible for tissue injury: shear stress due to shock front distortion and cavitation induced in the blood vessels ***(Zhu et al., 2004 a).***

First a single unit Ellipsoidal reflector was inserted to modify the profile of the SW to suppress the cavitation selectively in tissues along the propagation path of SWs and thus decreasing the vascular injury. Second, a piezoelectric annular array (PEAA) generator was inserted to produce an auxiliary SW to intensify the collapse of SW – induced bubbles near the target stone for improved comminution***(Zhou and Coworkers, 2004).***

Further evaluation of efficacy and of safety of dual pulse SWL was presented by (***Loskeet al., 2005).***In their study a piezoelectric, lithotripter was modified to produce pairs of successive (tandem) SWs with adjustable inter–Pulse time delay with no need for an extra generator. Another novel approach is the bidirectional synchronous twice–pulse technique which generates SWs simultaneously fromseparate reflectors through tow axes in non – opposing directions to the same F2 ***(Sheir et al., 2003).***

Since its introduction by Chaussy et al in 1980,swl has become the preferred treatment for renal calculi of <2 cm in diameter. The outcome of SWL depends on many factors, including size,location composition, fragility,the shock wave generator and the presence of obstruction or infection. After the introduction by (***Dretler)*** of the concept of fragility, stone composition has emerged as the main factor influencing the efficacy of SWL. Different techniques have been used to assist in determining the chemical composition of urinarystones in vivo. Such tests include PH, identifying and characterizing urinary crystals, the presence of urea – splitting organisms,bone densitometry and radiographic studies CT with on enhancement by contrast medium (NCCT) has long been used clinically to evaluate causes of radiolucent filling defects using measurement of substance density in Hounsfield units (HU) to distinguish calculi from tumors or blood clots As it provides greater density discrimination than a conventional plain abdominal film.It is now the preferred method to evaluate patients with renal colic its ability to detect density differences as low as 0.5% has been exploited to determine the composition and fragilityof urinary stones. The density of the stone varies with composition and affects the fragility of a calculus which ultimately governs the clinical outcome in SWL Hence it is vital to Know the fragility of calculus before SWL to increase the efficacy and reduce the number of hospital visits and thus cost.

Although plain abdominal x-ray film has been accepted as the first line diagnostic tool in the follow up after SWL with its cheap and practical use, the helical CT was found to be more valuable in the diagnosis of residual stone fragment which has not been found in plain abdominal x-ray. The routine use of helical CT can give more accurate information in patients control after SWL for both adult and pediatric patients ***(Kupeli et al., 2005).***

Some precautions concerning possible damages from SWL on the growing kidney have been raised in children. Preoperative evaluation included history, physical examinations, blood analysis, urinalysis, urine culture, intravenous urography. After treatment with SWL follow up by renal ultrasound, blood pressure monitor, laboratory tests, plain x-ray and dimercaptosuccinic acid **(DMSA)** found no renal scaring and no change in the renal function or blood pressure to pre-operative values***(Brinkmannet al., 2001)***.

History of SWl

It has been known for centuries that sound waves are focusable. The ancient Greeks used this knowledge to conversations of their imprisoned enemies. High – energy SWs have been recognized for many years. Examples of high energy-SWs include the potentially window – shattering sonic boom created when aircraft's pass beyond the speed of sound. Engineers at Dornier Medical Systems in what was then West Germany, during research on the effects of SWs on military hardware, demonstrated that SWs are reflectable and, therefore, focusable.The possibility of application of SWs to human tissue was discovered when, by chance, a test engineer touched a target body at the very moment of impact of a high-velocity projectile,the engineer felt a sensation similar to an electric shock although the contact point at the skin showed no damage at all ***(Hepp, 1984).(Quoted from Mohamed Abd al Ghany MD study 2008).***

In 1969, Dornier began studying the effects of SWs on tissues, specifically, to determine if SWs generated by projectiles hitting the wall of a tank would damage the lungs of a tank crew member leaning against the same wall.During this study, Dornier engineers developed techniques to reproducibly generate SWs and fount that SWs generate in water could pass through living tissues, except for the lung without discernible damage but that brittle materials were destroyed. At this point, a possible medical application becomes apparent. If SWs could safely pass through tissues but fragment brittle materials perhaps they could be used to break up kidneystones. Subsequently, Dornier engineers found that the lower- energy SWs appropriate for medical application could be generated by an electric spark discharge underwater and predictably reproduced ***(Lingeman et al., 2007).***