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ORIGINAL ARTICLE

Extracorporeal Shock Wave Lithotripsy (ESWL): An Evaluation of Success in Low, Medium and High Stone Density

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ABSTRACT

Objective: To find the frequency of patients of renal calculi with different stone densities and to evaluate the success rate of ESWL treatment in selected groups of patients i.e. low, medium and high stone density.

Methodology: In this descriptive case series, at Department of Urology, Services Hospital, Lahore was conducted and enrolled a 100 cases with single, radiopaque renal stone of 1-2 cm (10 to 20 mm), between 15-80 years of either gender whereas those with calculus in nonfunctioning kidney (GFR less than 15 ml/min), calculus in Pyonephrotic kidney, presence of JJ stent and having previous surgery for stone on same side or radiolucent stones were excluded from this study. All sessions of ESWL were performed following departmental protocol. 3 weeks after the ESWL session, the outcome was evaluated by plain X-ray KUB and USG KUB. In this analysis, ESWL success was defined as either total stone clearance or the presence of clinically insignificant residual fragments (CIRFs) (4 mm, peripheral, not producing renal colic, with no infection or extensive hematuria).

Results: Stone density was in the range of 335-1900 HU with a mean density of 851.1 (±418) HU. Patients with medium density group (500-1000HU) were significantly greater than other two groups. MDG had frequency of 51% followed by LDG (25%) and HDG (24%). Overall, ESWL success rate was 82% in all the 100 patients of renal calculi. Success rate was greatest in LDG i.e. 100%. MDG had a success rate of 90% and only 45.8% of the patients in HDG had succees after ESWL treatment. Success rate decreased as the stone density increased.

Conclusion: the stone density has a significant impact on success of ESWL. NCCT stone characteristics like mean density in HU and demographic characteristics are potential predictors for evaluation of success of ESWL.

Keywords: Kidney stones, ESWL, Stone density

INTRODUCTION

Renal stone disease is a major public health issue that affects people all over the world. A disease that affects 8% to 15% of the American populations. Urinary calculi have a morbidity incidence of 2% to 4%, which is comparable to diabetes. Stone therapy in the majority of patients has long been a source of contention among urologists. Surgical intervention was historically used to remove complex stones. However, ESWL and other minimally invasive modalitieis have essentially supplanted surgical management of urolithiasis (ESWL).[1] As an alternative to ureteroscopy for the treatment of ureteral calculi, endoscopic stone removal (ESWL) has been found to be effective in the treatment of kidney stones up to 2.0 cm in size. Stone size, density, skin-to-stone distance, excretory system architecture, and renal anomalies are just a few of the technical parameters that must be considered for optimal outcomes.[1-2]

The optimum treatment for calculi smaller than 20 mm is typically ESWL. The success rate varies between 60 and 90% in different series, although the effectiveness of this therapy depends on a number of variables, including the size, shape, placement, and composition of the stone.[1] Numerous studies have shown that patient demographics including age, gender, location, size, and attenuation value histogram of ureteric calculi may have an impact on the calculus-free rate after ESWL. The consistency, size, form, position, and attenuation value of urinary calculi evaluated in Hounsfield unit (HU) density and body mass index (BMI) may be indicators of shock wave lithotripsy (SWL) success as measured by the stone-free rate, according to some of these research (SFR).[3,4] Traditionally, the two techniques of choice for identifying renal calculi were ultrasound and intravenous urography. Non-contrast computed tomography (NCCT) has taken the position of intravenous urography as the primary modality for diagnosis and therapy in recent years. This is due to the NCCT's superior speed and accuracy in comparison to intravenous urography (IVU). Failure of the SWL leads to more surgeries and higher medical expenses.

Pakistan is situated within the stone disease's geographic range. The most prevalent urological condition in Pakistan is urolithiasis. The age range of the affected population in Pakistan is 40 years. ESWL therapy for individuals with renal calculi has been shown to be successful in a few small trials done in local settings. In several earlier investigations, the influence of demographic and stone features on the success rate of ESWL has been thoroughly described. In Pakistan, no study done for examining the influence of stone size, density, and stone-to-skin distance on the success rate of ESWL. However, there are currently insufficient numbers of NCCT studies to predict ESWL success in local contexts.

We planned to carry out a research to determine the frequency of various stone densities and SWL success in our area. The goal of this study is to identify the stone properties, such as density, and examine how these affect Pakistan's ESWL success rate. The purpose of this study was to estimate the frequency of various stone densities and assess the success rate of ESWL in those patients.

METHODOLOGY

In this descriptive case series, at Department of Urology, Services Hospital, Lahore was conducted and enrolled a 100 cases with single, radiopaque renal stone of 1-2 cm (10 to 20 mm), between 15-80 years of either gender whereas those with calculus in nonfunctioning kidney (GFR less than 15 ml/min), calculus in Pyonephrotic kidney, presence of JJ stent and having previous surgery for stone on same side or radiolucent stones were excluded from this study. All sessions of ESWL were performed by same operator. Vitals were taken before procedure. Stones were located on fluoroscope. A water cushion was used as a coupling medium. Patients were given analgesic injection Nelbuphin 2mg I/v if required to tolerate shock wave lithotripsy. The launch intensity energy was started from 0.5 and was increased gradually up to 7. Shocks were given at rate of 60 shocks/min with maximum of 2000 shocks/session or the treatment was stopped if complete fragmentation took place. Outcomes were evaluated 3 weeks after ESWL session by plain X-ray KUB and USG KUB. In this research, success with ESWL was defined as either full stone clearance or the presence of clinically unimportant residual fragments, also known as CIRFs (less than 4 millimetres in size, peripheral, not producing renal colic, and without extensive hematuria or infection). The data that was collected was input into version 16 of the SPSS programme. The value of p less than 0.05 was chosen as the criterion of statistical significance. For each of the analysed

variables, a set of descriptive statistics was calculated. These statistics included means, standard deviations, frequencies, and percentages (quantitative as well as quantitative). An analysis of variance with one factor was carried out to determine the degree of significance between the three groups (Low, medium and high).

RESULTS

According to the findings, the age group of 31 to 45 years old had the greatest prevalence of individuals suffering from renal stones (39%). The age group of 15-30 years old had the second highest incidence of renal stones at 28%, followed by the age group of 46-59 years old at 19%. According to the findings of this research, the elderly population (those aged 60–80 years) had the lowest incidence of renal calculi (14%). In this particular research, the patients who had renal calculi had an average age of 40.7 years, with a standard deviation of 15 years. It has been shown that men, as a fraction of the population, have a higher prevalence of renal calculi than females. In the current investigation, men accounted for 65% of patients diagnosed with renal calculi, while females made for 35% of the total.

All the patients of renal calculi were divided into three groups in the present study s on the basis of stone density as follows:

1. Low Density Group (LDG) = Patients with stone density < 500HU
2. Medium Density Group (MDG) = Patients with stone density 500-1000 HU
3. High Density Group (HDG) = Patients with stone density > 1000HU

The results regarding the frequency of patients in each group are presented in the Table 1. Results showed that stone density in the present study (total of 100 patients) was in the range of 335-1900 HU with a mean stone density of 851.1 (±418) HU. Most of the patients reported to Department of Urology, Services Hospital, Lahore were having renal stones of medium density i.e. in range of 500-1000HU. Frequency of patients in this group i.e. Medium density group was 51% of all the patients reported with renal calculi. Range of stone density in this group was from 511 HU to 998 HU. The mean stone density of the patients of this group was 743.5 (±136.9) HU.

MDG group was followed by LDG i.e. low density group. Frequency of patients of renal calculi with low stone density was 25% of all the patients reported to Department of Urology, Services Hospital, Lahore. Stone density in this group was in the range of 335 HU to 499 HU. The mean stone density in all 25 patients of this group (LDG) was 441.1 (±43.9) HU. This group was the second largest group of patients of renal calculi as shown by present study.

Frequency of HDG i.e. high density group was least of all the three groups defined in the present study. High density group was designed for those patients who had renal stone density greater than 1000 HU as detected by NCCT in the present study. Overall, 24% of the patients were reported with high density stones in their kidneys. Range of stone density in this group was from 1022 HU to 1900 HU. The mean stone density of patients in high density group was 1506.8 (±237.5) HU. The order of frequency of three groups of patients with renal calculi was MDG > LDG > HDG in this study.

Table 2 defines success/failure rate of ESWL.

Figure 1 clearly shows that success rate was much lower in MDG (Medium density group) and HDG (High density group). ESWL Success rate in MDG was 90.2%. That means that 46 out of 51 patients of this group successfully finished the ESWL treatment. Only 5 patients had still residual stone particles > 4mm after 3 consecutive ESWL sessions. The failure rate was 9.8% in this group. ESWL outcome in high density group i.e. HDG was considerably different from two former groups. There were a total of 24 patients treated in this group. All these patients had stones with density > 1000HU in their kidneys. Results showed that out of 24, only 11 patients had success after ESWL sessions. Rest of 13 patients still had stone particles in their kidneys. Success rate of ESWL in this group was least i.e. 45.8%.

Table 1: Frequency of Patients within Different Stone Density Groups (n=100)

Stone density levels	No. of patients in each density group	% of each density group	Mean ± SD (Hounsfield units)	Range (Hounsfield units)
LDG	25	25	441.1±43.9	335-499
MDG	51	51	743.5±13609	511-998
HDG	24	24	1506.8±237.5	1022-1900
Total	100	100	851.1±418	335-1900

LDG = Low density group (<500 HU)
MDG = Medium density group (500-1000 HU)
HDG = High density group (>1000HU)

Table 2: ESWL treatment outcome according to stone density groups (n=100)

Stone density levels	Total No. of patients (%age)		
	ESWL success	ESWL failure	Total Number
LDG (<500 HU)	25 (100%)	0 (0%)	25 (100%)
MDG (500-1000 HU)	46 (90.2%)	5 (9.8)	51 (100%)
HDG (>1000 HU)	11 (45.8%)	13 (54.2)	24 (100%)
Total	82 (82%)	18 (18%)	100 (100%)

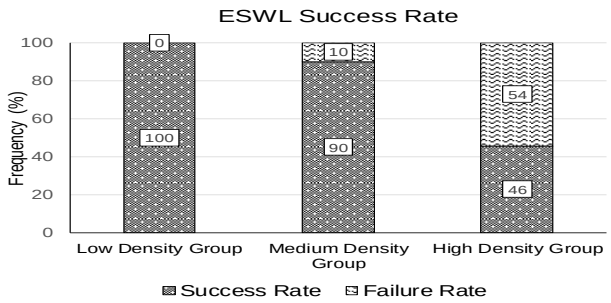

Figure 1: Frequency of ESWL outcome in the form of success and failure rate in three density groups.

DISCUSSION

Due to its minimally invasive nature, lack of need for anaesthesia, and low morbidity, ESWL has been recognised as the ideal approach for treating renal and/or ureteric calculi since the 1980s.[1] The results of ESWL were dependent on a wide range of variables, including stone size, density, location, composition, radiological features, shockwave generator type, and the presence of blockage or infection, according to several research undertaken in the past.[1,5-11] The correlations between radiological traits, stone composition, and ESWL performance have been the subject of several investigations. The therapeutic result of ESWL is ultimately controlled by the fragility of the calculus, which is influenced by the density of the stone, which varies with its composition. Shah et al.12 discovered that as the HU density rises, more shocks are needed to cause stone fragmentation. Additionally, the relationship between the mean shock intensity and the HU density of the stone is proportional. Peak and mean HU densities have been shown to be reliable indicators of SWL performance in univariate analysis, according to Bandi et al. HU density has been demonstrated to be highly correlated with ESWL success and was so in our data as well.

The effectiveness of this treatment for patients with renal calculi depends on a variety of factors, including the composition of the stone, where it is located, the anatomy of the pelvic cavity, and the size and density of the stone. ESWL is still regarded as the best treatment for calculi less than 20 mms. 1,14-17 Although stone properties appear to be the most crucial factor in treatment outcomes, it is still impossible to determine with certainty prior to stone extraction and examination. By comparing the density of the

stone with the density of the bone, plain x-ray has been utilised to forecast the results of ESWL therapy. However, this approach has some drawbacks since the density assessment is subjective and the stone diameter and appearance measurements may not be precise, particularly when there is intestinal gas interference or nearby bony structures.[1] Contrary to plain x-ray, which can only differentiate density changes of 5%, CT may detect variances as small as 0.5%.[1,18] According to the literature, fragmentation of stones with a CT attenuation value of more than 950 Hounsfield units and 7500 shockwaves was unsuccessful.[15]

The study's findings demonstrated that a stone density of less than 759 HU suggested a successful ESWL result. Our findings concur with those of Tarawneh et al[15], who said that when the CT attenuation value was less than 750 Hounsfield units, the effectiveness of the ESWL therapy was virtually always assured. Conversely, when the CT attenuation value exceeded 950, the treatment failed almost invariably. In their investigation, stone densities between 750 and 950 may or may not react favourably to ESWL therapy.[15] However, Tarawneh et al. found that stones with diameters up to 20 mm may still be effectively treated with ESWL (depending on stone density).[15] The findings of this investigation clearly demonstrate that stones with density beyond 950 Hounsfield units are difficult to fragment, similar to Tarawneh et al. The efficacy of ESWL therapy for stones 20 mm or smaller is determined by stone density, according to the study's findings.

Few clinical research have currently evaluated the stone density with the in vivo results of ESWL. These studies are lacking to find in Pakistani local settings. A study by Joseph et al.19 involving 30 patients found that those with calculi less than 500 Hounsfield units were completely cleared after a median of 2500 shockwaves, those with calculi between 500 and 1000 Hounsfield units had an 86% clearance rate and required a median of 3390 shockwaves, and those with calculi larger than 1000 Hounsfield units had a 55% clearance rate and required a median of 7300 shockwaves.

Clearance rates of 42% were achieved for stones with density greater than 1000 Hounsfield units, and a median clearance distance was necessary. Pareek et al.[20] found a correlation between calculus density and stone expulsion. They arrived at the result that the mean calculus density for those who had residual calculi was more than 900 Hounsfield units.

According to the results of this investigation, which are consistent with the findings of Pareek et al.20, the removal of stones becomes very unlikely until the stone density reaches 950 Hounsfield units or above. The results of this research, which reveal that there is an inverse link between the density of stones and the success rates of ESWL, complement the findings of Joseph et al.[19].

CONCLUSIONS

In conclusion, the outcome of ESWL therapy is substantially but negatively related to stone density. According to the current study, stones with CT densities of 759 Hounsfield units or less are successfully treated with fewer shock waves and sessions. A stone density of 1267 HU or more indicates lower success rate of ESWL.

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