ORIGINAL ARTICLE

SIGNIFICANCE OF HOUNSFIELD UNITS ON NON-CONTRAST COMPUTED TOMOGRAPHY IN DETERMINING THE STONE-FREE RATE AFTER ESWL

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ABSTRACT

OBJECTIVE: To determine the frequency of stone-free rate after extracorporeal shockwave lithotripsy (ESWL) and its relationship with Hounsfield Units (HUs) of renal calculi. **METHODOLOGY:** This observational study was carried out at the Department of Urology, Sindh Institute of Urology and Transplantation (SIUT), Karachi, Pakistan, from June 2015 to December 2015. All patients were evaluated for serum creatinine, coagulation profile, urinalysis and culture and imaging studies including non-contrast computed tomography (NCCT). All were evaluated with X-ray and ultrasound KUB at six weeks of ESWL session. Patients with residual fragments more than 4 mm in size were offered another session of ESWL. In case of persistent stone fragments more than 4 mm in size, stones were labeled as ESWL-refractory and alternative treatment options offered. **RESULTS:** A total of 139 patients were included in this study. The mean age was 40.0 ± 8.9 years and 91 (65.47%) were males. The mean stone size and mean HUs of all patients were 12.7 ± 3.6 mm and 616.9 ± 304.3, respectively. On last follow-up, out of 139, 95 (68.3%) patients were in stone-free group and 44 (31.6%) in residual stone group, with a mean HUs value of 565 ± 62.1 and 905 ± 61.7, respectively (p=0.001). The mean HUs of stone-free group was significantly lower than that of residual stone group. **CONCLUSION:** Our findings suggest that the HU measurement of renal calculi on pretreatment NCCT might be helpful in predicting stone-free rate after ESWL.

Key Words: Renal stones, Extracorporeal shockwave lithotripsy, Hounsfield units.

Introduction

The incidence of renal stone is increasing worldwide.[1] Fear of open surgery is one of the main reasons for delay in seeking treatment and results in complications of stone disease. This fear has been reduced by the use of extracorporeal shockwave lithotripsy (ESWL).[2] During the last three decades, ESWL has proven to be an effective, non-invasive treatment modality for most upper urinary tract stones, especially those smaller than 2 cm.[3,4]

The success rate of ESWL varies from 69.5% to 90%.[2,3] This success depends on many patient- and stone-related factors. Failure to stone fragmentation results in unnecessary exposure of renal parenchyma to shock waves and the requirement of an alternate procedure, which increases medical cost. Therefore, it is important to identify patients who could benefit most from ESWL before treatment.

In order to select proper treatment option for urinary stones, radiographic assessment of the calculus is necessary. Plain X-ray of the kidney, ureter and bladder (KUB), ultrasonography and excretory urography have traditionally been done to provide information impor-

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tant in the management of urinary calculi. Recently, non-contrast computerized tomography (NCCT) has become the choice of imaging as it provides rapid and accurate stone parameters.[5] Many studies have been done to correlate the radiographic findings on NCCT, including consistency, size, shape and location, with treatment success but no specific recommendations have yet resulted from these studies.[5,6]

In vitro studies suggest that the attenuation value of calculi measured in hounsfield units (HUs) on NCCT may predict the ability to fragment urinary stones. Stones traditionally treated with ESWL may be better managed by other modalities based on the HU values obtained from NCCT.[6]

A previous study has shown significantly different mean values for stone-free and residual stone groups 551.2 ± 46.6 vs 926.20 ± 51.42HU, p <0.0001), respectively. They observed stone free rate in 64% of cases and residual stones rate in 36%.[7]

The present study was aimed to determine the significance of HUs on pretreatment NCCT in determining the stone-free rate after ESWL in our setting.

Methodology

The study which was conducted from June 2015 to December 2015 at the Department of Urology, Sindh Institute of Urology and Transplantation (SIUT), Karachi, Pakistan. Non-probability, consecutive sampling was done. Adult patients of either gender between ages of 20 to 50 years, having single stone, with a size of 8 to 20 mm were included in the study. Patients having congenital anomalies (horse-shoe shape kidney, pelvi-ureteric junction obstruction (PUJO), ectopic kidney, duplex system), deranged coagulation, serum creatinine >1.5 mg/dl, multiple stones on the same side, pregnancy, culture-proven urinary tract infection (UTI) were excluded.

After written informed consent, patients were evaluated and selected from the stone clinic and urology emergency room. All patients were evaluated for serum creatinine, coagulation profile, urinalysis and culture. All patients also underwent ultrasonography and X-ray of kidney, ureter and bladder (KUB). The indications for ESWL were determined by the stone size and location. The HUs for each stone were determined on pretreatment NCCT scan. Patient's demographic data, age, sex, body weight, stone size and location, and stone's attenuation value were documented on a proforma. All ESWL procedures were performed on a second generation electrohydraulic lithotripter Doli [Doli 50 (1995 Make), Dornier, Germany] by postgraduate trainee under supervision of the consultant. Calculi were fragmented under fluoroscopy and/or ultrasound guidance. The number of shock waves delivered and energy level in kV, haematuria, and flank pain were also recorded. All patients were evaluated with X-ray and Ultrasound KUB at six weeks of ESWL session. Patients were categorized into a stone-free status and significant residual fragments groups.

Patients with residual fragments more than 4 mm in size were offered another session of ESWL. Repeat ultrasonography and X-ray KUB was done at six weeks interval of second session. In case of persistent stone fragments more than 4 mm in size, patients were labeled as having ESWL- refractory stones and alternative treatment option was offered.

The data was entered and analyzed using Statistical Package for Social Sciences (SPSS) version 18.0 (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics were used. Continuous variables such as age, size of stones were presented as mean ± standard deviation (SD), while numbers and percentages (frequencies) were used for categorical variables such as frequency of stone clearance. Effect modifiers were controlled through stratification of age, gender and stone size to see the effect of these on outcome variables and applying chi-square test post-stratification. p value of ≤0.05 was taken as significant.

Results

A total of 139 patients were included in this study. Their mean age was 40.0 ± 8.9 years. Among these, 91 (65.4%) were males and 48 (34.5%) females. The male to female ratio was 1.8:1.

The mean stone size and HUs of all patients were 12.7 ± 3.6 mm and 616.9 ± 304.3 HUs, respectively. On last follow-up, out of 139, 95 (68.3%) patients were in stone-free group and 44 (31.65%) in residual stone group, with a mean HUs value of 565 ± 62.1 and 905 ± 61.7, respectively, which was statistically significantly different (p=0.001), as shown in (Fig. 1).

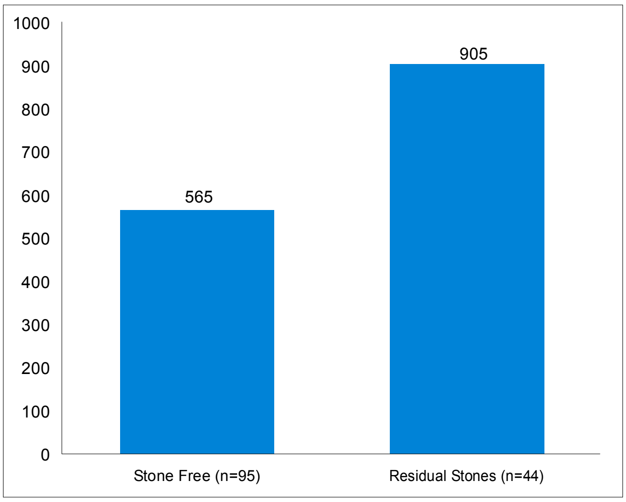

Figure 1: Comparison of Hounsefield units of stones showing significant difference in stone-free and residual stone groups (p<0.001).

With respect to age of the patients, the rate of stone clearance was high in >40 years age group as compared to <30 years of age group. However, there was no statistically significant difference between the above age groups (p=0.226). The rate of stone clearance was 70.3% (64/91) in males and 64.6% (31/48) in females, but there was no statistically significant difference between males and females (p=0.48). Similarly, the rate of stone clearance was also not significantly different among the different sizes of stones (p=0.095) as presented in (Tab. 1).

Stone Size (mm)	Stone clearance	Treatment Failure	Total	P-Value
8 to 10.9 mm	42 (79.2%)	11 (20.8%)	53	0.095
11 to 15.9 mm	32 (61.5%)	20 (38.5%)	52	
16 to 20 mm	21 (61.8%)	13 (38.2%)	34	

Table 1: Frequency of stone-free rate after extracorporeal shockwave lithotripsy of renal calculi with different Hounsefield units with respect to stone size.

Discussion

Currently, ESWL is the most common mode of therapy for small renal stones.[8] Stones are first disintegrated by shock waves, and then fragments are spontaneously cleared from the urinary tract. Failure of stone disintegration results in unnecessary exposure of the renal parenchyma to shock waves and the requirement of an alternative treatment procedure, which increases the medical costs. Hence, it is important to identify patients who will benefit from ESWL prior to treatment by examining the stone fragility.

Many investigators have studied the usefulness of NCCT for evaluating urinary calculi and observed that it is superior to traditional imaging such as excretory urography, making it the preferred imaging modality. NCCT can provide an abundance of information on urinary tract calculi, including size, shape, number and location. In addition, the attenuation value of calculi measured in HUs obtained from NCCT may be used to predict stone composition. In an effort to obtain more information, a recent in vitro study was done to correlate HU values obtained on NCCT with the ability to fragment calculi.[9] This study provides compelling data suggesting the importance of measuring HU in all patients who undergo NCCT to evaluate renal calculi.

We performed an in vivo study to corroborate these findings. By evaluating patients undergoing ESWL for renal calculi, we determined whether the success of this procedure could be predicted by pre-treatment HU values measured on NCCT.

The ability to assess renal tract stone characteristics and determine susceptibility to fragmentation is not a new phenomenon. In an early study, Chaussy and Fuchs compared stone radio-density with that of the spine and concluded that stones are less likely to break if their radio-density is greater than that of the spine.[10] Others studied the opacity of calculi of similar sizes and concluded that fragmentation is less likely with higher opacity.[11] Although these studies provide insight into information needed for therapeutic considerations, they were based on qualitative observations, making them highly subjective and difficult to standardize.

Therefore, we assessed stone opacity using a quantitative measurement to evaluate treatment outcomes. HUs calculated on pretreatment NCCT in patients who underwent ESWL provide a simple, easily reproducible and readily available measure of stone opacity. The frequency of stone-free rate after ESWL in various HUs of renal calculi was 68.35% (95/139) in this study. Similar result was also reported in the study by Pareek et al. who showed 64% stone-free rate and 36% residual stones rate with significantly different mean HU values for stone-free and residual stone groups (551.2 ± 46.6 vs 926.20 ± 51.42, p<0.0001), respectively.[12] Pareek et al. had evaluated

100 patients who had undergone ESWL.[12]

Many factors influence ESWL success, including the type of lithotripter. First-generation lithotripters are more powerful and successful at stone fragmentation. An overall success rate of 68% with a Dornier Doli-S has been obtained in our study. Overall, success rates of 48% to 86% have been reported by other authors with the same lithotripter.[13]

Slower shock rates have also been reported to result in higher success rates.[14] Several patient characteristics have been reported to influence ESWL success. Some investigators reported that older patients are less likely to have successful ESWL therapy.[15]

In our study, the rate of stone clearance was also insignificantly different among the stones of different sizes (p=0.095). Stone characteristics, such as size and location, have been reported as significant predictors of ESWL success by other authors.[16]

Stone composition determination on NCCT has been of considerable interest. In vitro studies showed a correlation of composition with HUs on NCCT.[17] Other investigators have reported that HU determination on NCCT does not predict stone composition.[18] Specifically, the mean values of calcium, uric acid, struvite and cystine stones were compared (440 ± 262, 270 ± 134, 401 ± 198 and 248 ± 0 HU, respectively). The HU value as an independent predictor of stone composition did not show a significant difference among stones. However, the study revealed the greatest difference in HUs for calcium vs. uric acid stones. A possible explanation for this finding was the low number of uric acid stones in the study.

Recent studies have used high-resolution CT protocols to predict the outcome of ESWL. The results have been conflicting and show ethnic differences.[19] Gallioli et al. studies the utility of HU demonstration in determining the stone composition and outcomes in percutaneous nephrolithotomy (PCNL) and concluded that HU parameters are useful in selecting patients for treatment and in predicting outcome.[20]

Conclusion

Our findings suggest that the HU measurement of renal calculi on pretreatment NCCT might be useful in predicting the stone-free rate after ESWL. Further, large-scale studies are needed to corroborate these findings.

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