ORIGINAL ARTICLE

EFFECT OF CT SCAN HOUNSFIELD UNITS (ATTENUATION VALUE OF STONES) IN PREDICTING OUTCOMES OF ESWL IN RENAL CALCULI, EXPERIENCE AT SIUT

Ameet Kumar Lalwani,[1] Munawar Khaliq,[2] Syed Muhammad Faiq,[1] Ameet Kumar Jesrani[1]

[1] Department of Radiology, Sindh Institute of Urology and Transplantation (SIUT), Karachi, Pakistan.
[2] Department of Urology, Sindh Institute of Urology and Transplantation (SIUT), Karachi, Pakistan.

PJR July - September 2021; 31(3): 160-165

ABSTRACT

BACKGROUND: CTscan Hounsfield unit is considered investigation of choice in planning management of renal stones to influence surgical strategy and it defines hardness of stones so that high density stones should be excluded from ESWL. **THE OBJECTIVE:** Of this study was to evaluate the utility of the Hounsfield Unit (HU) values as a predictive factor of extracorporeal shock wave lithotripsy outcome for renal stones. **MATERIALS AND METHODS:** A prospective study was performed to measure stone HU values in 445 patients who underwent extracorporeal shock wave lithotripsy (ESWL) for solitary renal stones from December 2019 to January 2021. Stone size stone location, stone HU values, and stone composition were assessed. Success of ESWL was defined as: (1) being stone-free or (2) residual stone fragments <4 mm after 3 months by x-rays and ultrasound. **RESULT:** Total no of patients in our study included 445 cases, out of which males are 300 (67.41%) and females are 145 (32.58%). Total no of patients in which successful ESWL with stone lysis noted in 272 (61.12%) and in 173 (38.88%) patients ESWL was not successful. **CONCLUSION:** In this prospective study, we found CTscan Hounsfield unit is very helpful in predicting successful outcomes of ESWL in renal calculi.

Key Words: CT scan (computed tomography), HU (Hounsfield unit), ESWL (Extra corporeal shock wave lithotripsy).

Introduction

One of the most common disease in field of urology is urolithiasis which is affecting 5% of women and 12% of men in their life time.[1] Urolithiasis is a common problem in our country (Pakistan lies within the stone belt region extending from Indonesia to Egypt) falling within tropical and subtropical regions which were constantly reporting high number of stone disease.[2] Reasons which are behind high incidence of urolithiasis in this regions due to high densely populated areas, low intake of water even with hot and humid climate, malnutrition and poverty.[3] Stone disease is third most common cause in urological admissions in Pakistan.[4] Urolithiasis constitutes 40-50% of the urological workload in hospitals.[5] A specific problem of this region is the neglected asymptomatic large and/or staghorn calculi which present with renal failure.[6]

Urolithiasis can be conservatively managed or by Surgery. ESWL is another option.[1] In 1980 ESWL was introduced which is non invasive procedure and does not require anaesthesia.[7] It is considered as the first-line treatment of urinary tract stones with a success rate of 80-90%.[1]

Stones of <1.5 cm in diameter are preferably treated by ESWL with success rate of 60 to 99%. Composition of stone is main factor affecting the outcomes of

Correspondence : Dr. Ameet Kumar Lalwani
Department of Radiology,
Sindh Institute of Urology and Transplantation (SIUT),
Karachi, Pakistan.
Email: dramitsl@yahoo.com

Submitted 23 July 2021, Accepted 25 August 2021

ESWL, while other factors are size of stone, its location, and anatomy of pelvicalyceal system, body mass index (BMI), the shock wave generator and the presence of obstruction or infection.[8,9] The stone composition has emerged as the main factor influencing the efficacy of ESWL.[10]

The use of ESWL in the treatment of renal stone disease is gradually increasing in Pakistan. This is associated with the progressively increasing availability of Extracorporeal shock wave lithotripters.[3] Since its first introduction in 1989 in Pakistan, the number of lithotripters has reached in many institutes even rural areas now which are catering for a population of 220 million With the increasing use of ESWL, urologists are being frequently confronted with its limitations and complications.

CTscan Hounsfield unit is considered investigation of choice in planning management of renal stones to influence surgical strategy.[11]

Sir Godfrey Newbold Hounsfield first introduced the principle to quantify the amount of X-rays that pass through or are absorbed by tissues. HU have since been used to evaluate and quantify tissues and fluids. When the radio density of water is defined as 0, fat has a negative HU, and blood and other tissues have a positive HU. Using this method it is possible to differentiate 256 shades of gray that are indistinguishable to the naked eye.[12]

Non Contrast CT scan can properly evaluate the composition of stone (attenuation value) in urinary tract which is of utmost importance prior to ESWL because failure of ESWL results in wasted medical costs, deterioration in patients with obstructed kidneys, unnecessary exposure to ionising radiation and to shock waves. So it is very important to do Non Contrast Ct scan prior to ESWL for achieving better results.

Material and Methods

This study was prospective observational study. It was performed on 445 cases in Radiology and Urology Departments of SIUT after the institute ethical committee clearance and written consent from all patients will be taken.

In this study, adult patients of more than 18 years referred from Urology clinics and wards will be included.

Cases inclusion criteria include the patients with solitary renal pelvic and middle calyx stone of 0.5-1.5 cm on CTscan pyelogram.

Those patients were with evidence of distal urinary tract obstruction, grossly hydronephrotic kidneys with reduced renal function, prior renal surgery, post PCNL residual stones, ectopic kidney or malrotated kidneys, active infection, stone in the calyceal diverticula or lower calyces (as less chance to clear), cystinuria (cystine in urine) blood coagulation disorders, obesity, uncontrolled hypertension and pregnancy were excluded from the study.

Based on stone attenuation value (HU)>1000, the ESWL success was 24.5% 13 with 95% confidence interval and margin of error 4% , a total of 445 patients will be required for this study.

After obtaining the informed consent for the patients meeting the inclusion criteria demographic details (age, gender) and CT scan findings (stone size, site, mean stone density (HU)) was noted in pre designed Performa within one week prior to perform ESWL. (Fig.1)

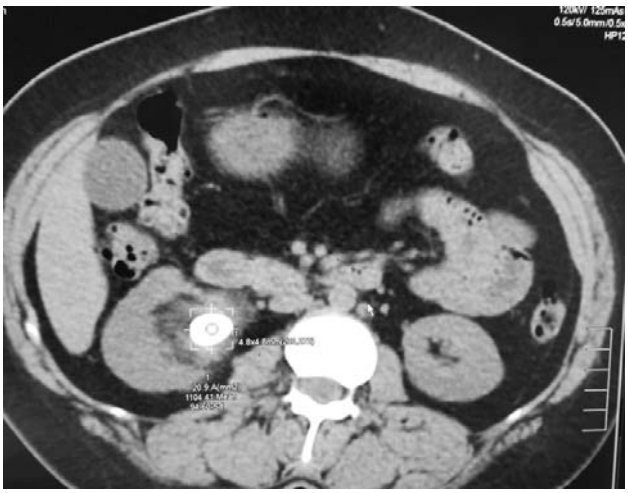


Figure 1: CT scan pyelogram plain study (axial plane) at level of kidneys, Renal calculus was noted in renal pelvis of right kidney having HU (1104) with peri pelvic fat stranding and mild obstructive uropathy

ESWL machineSLXF2 STORZ was used with 3000 Shockwaves with energy of 6.0. (Fig.2)

• All the patients were divided into three groups according to HU field unit values.

Group 1 patients will have SAV of ≤ 500 HU unit.

Group 2 patients have SAV of 501-1000 HU

Group 3 patients have SAV of > 1000 HU.

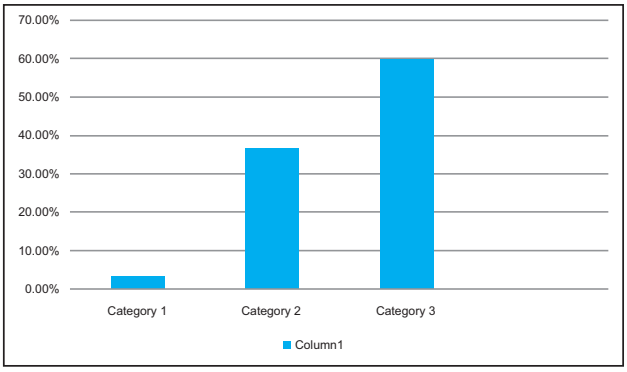
Figure 2: Patient in prone position (ESWL ROOM) and stone was localized by using ultrasound machine.

Figure 3: Renal stone was targeted by ultrasound guided lithotripsy machine

• Observation was made by noticing SAV up to 2 locations in case 0.5 cm stone, SAV up to 4 locations in case of 1.5 cm stone and then mean attenuation values of stones have been taken on non-contrast CT scan and ESWL was performed by senior operators having experience more than 3 years.
Later it was checked the outcome of ESWL on different stones with different attenuation values in follow up in OPD after four weeks and ultrasound KUB was be performed to assess the stone clearance.
If there is residual stone fragment on ultrasound then maximum three settings of repeat ESWL will be done for stone fragments or clearance with gap of at least two weeks for period of 3 months.

Results

Total no of patients in our study were included 445 cases, Out of which males were 300 (67.41%) and females were 145 (32.58%). Age of patients was from 20 years to 67 years with mean age of 45 years.
We had categorized patients into 3 categories based on Hounsfield units of stones, among them category 1 (HU <500) included 15 patients (3.37%), category 2 (HU 500-1000) included 164 patients (36.85%) and category 3 (HU >1000) included most number of patients in our study and were 266 (59.77%) (Tab.1).
Frequency of stones according to size of < 1cm were noted in 58 patients (13.03%) and of > 1cm were noted in 387 patients (86.96%).



Category 1: Stone size less than 500 HU
Category 2: Stone size with HU b/w 500 to 1000
Category 3: Stone size more than 1000 HU

Table 1: Frequency of patients according to Hounsfield unit of stones in this study.

Total number of stones according to their location were noted in our study as in 409 (91.91%) patients stones were noted in renal pelvis while in only 36 (8.08%) patients stones were noted in middle calyx (Tab.2).

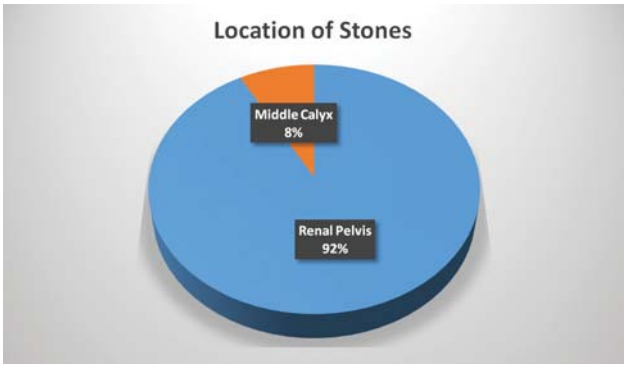
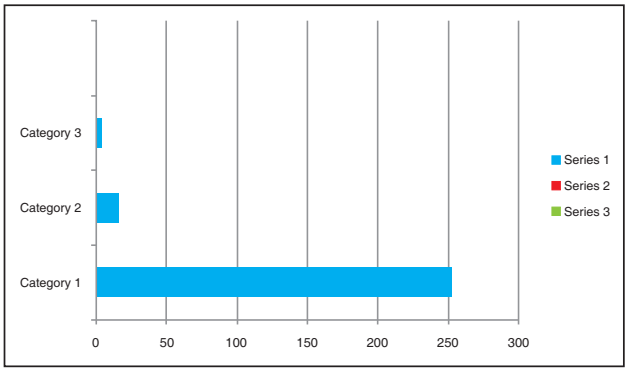


Table 2: Percentage of stones according to their location

In 252 (56.54%) of patients breakdown of stones were noted in 1st setting of ESWL, in 16 (5.8%) of patients breakdown of stones were noted in 2nd setting of ESWL and in only 4 (1.3%) of patients 3rd setting of ESWL was required in breakdown of stones (Tab.3).

Total no of patients in which successful ESWL with stone lysis was noted in 272 (61.12%) and in 173 (38.88%) patients ESWL was not successful.

Category 1 patients with stone HU < 500 were 15 and had success rate of 100%. Category 2 patients with stone HU of 500-1000 were 164 also had success rate of 100% in clearance of stone while category 3 patients with HU of >1000 were 266 and success rate in stone clearance was in 93 patients and unsuccessful were 173 patients so it was 35% in category 3 patients. Overall success rate was 61%.



Category 1: Stone size less than 500 HU
Category 2: Stone size with HU b/w 500 to 1000
Category 3: Stone size more than 1000 HU

Table 3: Percentages of patients and sessions of ESWL required breaking stones.

Discussion

As technology advancements are happening, use of unenhanced CTscan Hounsfield has gained wide spread acceptance in evaluation o nephrolithiasis since early 1990.

Because studies has shown that unenhanced CTscan can depict precise location of renal stones in urinary system and Hounsfield units can describe composition and density of stones than X-ray, sonography and intravenous urography (IVU) in order to stone clearance by applying EWSL.

Previous clinical and epidemiological studies showed that successful fragmentation of renal stones rely on several factors like stone location, size, consistency and composition of stones.[14]

Hameed et al[15] reported that successful fragmentation using ESWL was decreased in stones with HU > 1350, which required application of more shock waves.

El-Assmy et al[16] used the Hounsfield value of the stones to predict stone composition and density, and the fragmentation success using ESWL, and selected HU > 1000 as their cut off value. Another study of pediatric patients by the same group revealed that stones ≤ 600 HU and ≤ 12 mm in length were significant independent predictors of SWL success in children.[17]

Other studies, Ouzaid ET al[18] performed a prospective study on 50 patients, and reported that a HU threshold of 970 was predictive of successful ESWL.

Foda ET al[19] demonstrated that stone disintegration failed if the stone density was > 934 HU; therefore, they did not recommend ESWL in this group of patients.

By analyzing the effects of ESWL Popov et al[20] showed that low density stones, which are composed by the softer, after one or two sessions with ESWL, had effective therapeutic effects in 64.4% of patients. Patients who have had stones greater density, which are at the very composition also firmer, with the same number of sessions were effective therapeutic effects in a small percentage of patients. The same authors have also demonstrated that the stones size over 10 mm require the application of a number of sessions a treatment success.

The clearance rate of stones is located in the pelvis is higher than those located in the calyces. The clearance rate for upper pole stones is faster than for stones in the lower pole. Many kidney stones are located in the lower calyx and the most effective way to treat these stones is vigorously debated. In up to 35% of patients treated with ESWL, the lower calyces are incompletely cleared of disintegrated stone material.[21]

Conclusion

CTscan Hounsfield unit is important predictor for clearance of urinary calculi in ESWL. HU is clearly defines hardness of calculi so high density stones should be avoided for ESWL and surgery can be

taken so CTscan Hounsfield should be done in planning of management of renal calculi.

Conflict of Interest: None

References

1. Evaluation of extracorporeal shock wave lithotripsy (ESWL): efficacy in treatment of urinary system stones. Junuzovic D, Prstojevic JK, Hasanbegovic M, et al. Acta Inform Med. 2014; **22:** 309-14.

2. Hussain M, Lal M, Ali B, S A Naqvi, S.A.H Rizvi: Urolithiasis in Sindh: a single centre experience with a review of 10,000 cases. J NephrolUrol Transplant 1998; **1:** 10-3.

3. Rizvi SA H, Naqvi SA, Hussain Z, Hashimi A, Hussain M, Zafar MN, et al. The management of stone disease. BJU Int 2002; **89(1):** 62-8.

4. The prevalence of silent kidney stones-an ultrasonographic screening study. Buchholz NPN, Abbas F, Afzal M, et al. J Pak Med Assoc. 2003; **53:** 24-5.

5. Husain M, Lal M, Ali B et al. Management of urinary calculi associated with renal failure. J Pak Med Assoc 1995; **45:** 205-8.

6. Aegukkatajit S, Nagaphant A, Nuhung Ret al. Epidemiological study of urinary stones based on operative theater data at regional hospitals and general hospitals of public health region -5, Thailand. J Med Assoc Thai 1994; **77:** 484-7.

7. Stone clearance in lower pole nephrolithiasis after extra corporeal shock wave lithotripsy - the controversy continues. Ather MH, Abid F, Akhtar S, et al. BMC Urol. 2003; **3:** 1.

8. Martin TV, Sosa RE; Shock-wave lithotripsy. In Walsh PC, Retik AB, Vaughan ED Jr, Wein AJ eds, Campbell's Urology. Philadelphia: WB Saunders Inc, 1998: 2735-52.

9. Bon D, Dore B, Irani J, Marroncle M, Aubert J; Radiographic prognostic criteria for extracorporeal shock wave lithotripsy: a study of 485 patients. Urology 1996; **48:** 556-61.

10. Dretler SP; Stone fragility - a new therapeutic distinction. J Urol, 1988; **139:** 1124-7.

11. Turk C, Petrik A, Sarica K, et al. EAU guidelines on diagnosis and conservative Management of Urolithiasis. Eur Urol. 2016; **69:** 468-74.

12. CT Teaching Manual. Edited by Hoffer M. Verlog, Berlin: Springer;; 2007.

13. Waqas M, Saqib I, Jamil MI, Khan MA, Akhtar S. Evaluating the importance of different computed tomography scan-based factors in predicting the outcome of extracorporeal shock wave lithotripsy for renal stones. InvestigClin Urol. 2018; **59:** 25-31.

14. Pu YR, Manousakas I, Liang SM, Chang CC. Design of the dual stone locating system on an extracorporeal shock wave lithotriptor. Sensors (Basel) 2013 Jan; **13(1):** 1319-28.

15. Hameed DA, Elgammal MA, ElGanainy EO, Hageb A, Mohammed K, El-Taher AM, Mostafa MM, Ahmed AI. Comparing non contrast computerized tomography criteria versus dual X-ray absorptiometry as predictors of radio-opaque upper urinary tract stone fragmentation after electromagnetic shockwave lithotripsy. Urolithiasis. 2013; **41:** 511-5.

16. El-Assmy A, Abou-el-Ghar ME, el-Nahas AR, Refaie HF, Sheir KZ. Multidetector computed tomography: role in determination of urinary stones composition and disintegration with extracorporeal shock wave lithotripsy-an in vitro study. Urology. 2011; **77:** 286-90.

17. El-Assmy A, El-Nahas AR, Abou-El-Ghar ME, Awad BA, Sheir KZ. Kidney stone size and hounsfield units predict successful shockwave lithotripsy in children. Urology. 2013; **81:** 880-4.

18. Ouzaid I, Al-qahtani S, Dominique S, Hupertan V, Fernandez P, Hermieu JF, Delmas V, Ravery V. A 970 Hounsfield units (HU) threshold of kidney stone density on non-contrast computed tomography (NCCT) improves patients' selection for extracorporeal shockwave lithotripsy (ESWL): evidence from a prospective study. BJU Int. 2012; **110:** E438-E442.

19. Foda K, Abdeldaeim H, Youssif M, Assem A. Calculating the number of shock waves, expulsion time, and optimum stone parameters based on noncontrast computerized tomography characteristics. Urology. 2013; **82:** 1026-31.

20. Popov E, Donkov I, Slavov C, Georgiev M. Correlation of CT stone density and skin-to-surface distance with ESWL efficacy on lower pole kidney stones. AFJU. 2012; **18:** 53-4.

21. Pearle MS, Lingeman JE, Leveillee R alet. cm or lessProspective, randomized trial comparing shock wave lithotripsy and ureteroscopy for lower pole caliceal calculi 1. J Urol 2005; **173:** 2005-9.