Original Article

Role of Hounsfield Unit in Predicting the Outcome of Treatment of Renal Calculi with Extracorporeal Shock Wave Lithotripsy (ESWL)

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ABSTRACT

Objective: Objective of the study is to see the predictive accuracy of HU <934 in predicting the stone clearance in renal calculi with ESWL.

Study Design: Cross sectional study

Place and Duration of Study: This study was conducted at the Urology Department at Shaikh Zayed Hospital, Lahore from October 2019 to April 2020.

Materials and Methods: This study was carried out in the Department of Urology. A written informed consent was taken from all the patients included in the study after discussing risk and benefit ratio. Patients with stone density of more than 934 HU were informed about the lower chances of stone removal. All the patients were diagnosed and followed on the same CT scan machine (Multi detector CT scanner; Light speed VCT; 140kv/3.91mm) and were given treatment on the same lithotripter (STORZ Medical MODULITH SLX; 4thGeneration). Post ESWL antibiotics were given for three days, with oral analgesics if required. Patients were followed after maximum 4 sessions of ESWL over a duration of three months.

Results: The mean age of patients was 44.54±9.16 years with minimum and maximum age as 18 and 60 years. There were 134(55.8%) male and 106(44.2%) female cases. There were 197(82.1%) cases who had stone clearance and 43(17.9%) cases did not have stone clearance. There were 187 cases who had density as <934 and had tone clearance and 35(81.4%) cases had density ≥934 and did not have stone clearance while there were 8(18.6%) false positive and 10(5.1%) cases had false negative. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of density <934 was 94.92%, 81.40%, 95.90%, 77.78% and 92.50% respectively.

Conclusion: HU can be used for multiple purposes as it not only identify tumor in the renal system also it could tell about the characteristics of urinary stone. CT scan is equally effective for the determination of the stone composition and also determination of the efficacy of ESWL for the stone clearance.

Key Words: ESWL, Renal Stone, Hounsfield Unit, Ureter, Bladder

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INTRODUCTION

Urinary stones are the third most common pathological disease of the urinary tract. The prevalence rate of stones vary from 1 to 20%.[1] In developed countries where hygienic life style is opted such as Sweden, Canada, USA stone prevalence is notably high (>10%).The incidence of stones in Pakistan is high.[2] Stone disease outpatient number is more than half of all of the patients in a urological setting. Dornier, a German aircraft corporation, was investigating the pitting on supersonic aircraft; they discovered that shock waves originating from passing debris in the atmosphere can crack something that is hard. First clinical application with the name of Human model-1, was used in 1980, with successful fragmentation of renal calculi.[3] Extracorporeal Shock Wave Lithotripsy(ESWL) is considered to be the first line of treatment for Renal stone and success rate is reported to be 80-90%.[4, 5]

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Sir Godfrey Newbold Hounsfield was an English electrical Engineer, got Nobel Prize for physiology and medicine in 1979, for his part in developing CT scan. His name is immortalized in Hounsfield scale, a quantitative measure of radio-density used in evaluating CT scans.[6] Stone density in Hounsfield Units on Non-contrast computed tomography (NCT) found to be a prognostic feature for ESWL. El-Assmy et al used HU rate of stones to predict stone density and fragmentation success of ESWL and selected HU >1000 as their cut off value.[6] Ouzaid et al reported HU threshold of970 for the success of ESWL. Specifically stone free rate was96% and 38% with HU <970 and >970 respectively.[7] Foda et al demonstrated that stone dissolution unsuccessful if stone thickness was >934 HU.[8]

MATERIALS AND METHODS

Two hundred forty patients were taken using stone free clearance rate (successful ESWL) as 81.79% with sensitivity and specificity as 94.4% (assumed 90%) and 66.7% (assumed 90%) We used 95% confidence level and 10% margin of error. After approval from the hospital ethical committee, patients fulfilling the inclusion criteria were admitted on outpatient basis. A documented well-versed consent was taken from all the patients included in the study after discussing risk and benefit ratio. Patients with stone density of more than 934HU were informed about the lower chances of stone removal. All the patients were diagnosed and followed on the same CT scan machine (Multi-detector CT scanner; Light speed VCT; 140kv/3.91mm) and were given treatment on the same lithotripter (STORZ Medical MODULITH SLX; 4thGeneration). ESWL was performed by the Resident of Department of Urology. Post ESWL antibiotics were given for three days, with oral analgesics if required. Patients were followed after a maximum of 4 sessions of ESWL over a duration of three months. Stone clearance on HU and non- contrast was labeled (as per operational definition).

Results were generated with the use of Statistical Package for Social Sciences (SPSS) version 23.Mean± standard deviation was used for quantitative data. F(%) was used for qualitative data.2X2 contingency table was generated to determine diagnostic accuracy.

RESULTS

The mean age of patients was 44.54±9.16 years with minimum and maximum age as 18 and 60 years (Table 1).There were 134(55.8%) male and 106(44.2%) female cases(Table 2).The mean stone size was 13.76±3.78mm with minimum and maximum stone size as 6 and 20mm (Table 3).There were 85(35.4%) cases who had 6-12mm of stone size and 155(64.6%) cases had stone size as 12-20mm.There were 195(81.2%) cases who had <934 density and 45(18.8%) cases had density as ≥934. There were 187 cases who had density as <934 and had tone clearance and 35(81.4%) cases had density ≥934 and did not have stone clearance while there were 8(18.6%) false positive and 10(5.1%) cases had false negative. Diagnostic accuracy was estimated as 92.50%(Table 4). When diagnostic accuracy was estimated for age, it was observed that at age 18-40 year diagnostic accuracy was 97% and for age 41-60 years diagnostic accuracy was 90%. (Table5)Among male cases the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of density <934 was 94.69%, 76.19%, 95.54%, 72.73% and 91.79% respectively and among female cases the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of density <934 was 95.24%, 86.36%, 96.39%, 82.61% and 93.40% respectively. There was significant association with stone clearance and density with respect to gender, p<0.001 (Table 6).

Table No.1: Descriptive statistics of age (years) (n=240)

Age (years)	
Mean	44.54
S.D	9.16
Minimum	18.00
Maximum	60.00

Table No.2: Sex distribution of patients

Sex	No.	%
Male	134	55.83
Female	106	44.17

Table No.3: Descriptive statistics of stone size (mm)

Stone size (mm)	
Mean	13.76
S.D	3.78284
Minimum	6.00
Maximum	20.00

Among cases who had 6-12mm of stone size the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of density <934 was 100% for all and for patients who stone size 12-20mm the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of density <934 was92.00%, 73.33%, 93.50%, 68.75% and 88.39% respectively.

There was significant association with stone clearance and density with respect to stone size (Table 7).

Table No.4: Comparison of density in stone clearance

		Stone clearance		Total
		Yes	No	
Density	<934	187(94.9%)	8(18.6%)	195(81.2%)
	≥934	10(5.1%)	35(81.4%)	45(18.8%)
Total		197(100%)	43(100%)	240(100%)

P <0.001 (Highly Significant)

Sensitivity	94.92%
Specificity	81.40%
Positive Predictive Value	95.90%
Negative Predictive Value	77.78%
Diagnostic Accuracy	92.50%

Table No.5: Comparison of density in stone clearance with respect to age groups (years)

Age groups (years)	Density	Stone clearance		P value
		Yes	No	
18-40	<934	61(100%)	2(14.3%)	<0.001**
	≥ 934	0(0%)	12(85.7%)	
41-60	<934	126(92.6%)	6(20.7%)	<0.001**
	≥ 934	10(7.4%)	23(79.3%)	

**Highly Significant

	Age groups (years)	
	18-40	41-60
Sensitivity	100.0%	92.65%
Specificity	85.71%	79.31%
Positive predictive value	96.83%	95.45%
Negative predictive value	100.0%	69.70%
Diagnostic accuracy	97.33%	90.30%

Table No.6: Comparison of density in Stone clearance with respect to gender

Gender	Density	Stone clearance		P value
		Yes	No	
Male	<934	107(94.7%)	5(23.8%)	<0.001**
	≥ 934	6(5.3%)	16(76.2%)	
Female	<934	80(95.2%)	3(13.6%)	<0.001**
	≥ 934	4(4.8%)	19(86.4%)	

**Highly Significant

	Gender	
	Male	Female
Sensitivity	94.69%	95.24%
Specificity	76.19%	86.36%
Positive predictive value	95.54%	96.39%
Negative predictive value	72.73%	82.61%
Diagnostic accuracy	91.79%	93.40%

Table No.7: Comparison of density in Stone clearance with respect to Stone size (mm)

Stone size (mm)	Density	Stone clearance		P value
		Yes	No	
6-12	<934	72(100%)	0(0%)	<0.001**
	≥ 934	0(0%)	13(100%)	
12-20	<934	115(92%)	8(26.7%)	<0.001**
	≥ 934	10(8%)	22(73.3%)	

**Highly Significant

	Stone size (mm)	
	6-12	13-20
Sensitivity	100.0%	92.00%
Specificity	100.0%	73.33%
Positive predictive value	100.0%	93.50%
Negative predictive value	100.0%	68.75%
Diagnostic accuracy	100.0%	88.39%

DISCUSSION

The occurrence of nephrolithiasis is accounted for, expanding across the world. This expansion is considered notwithstanding to be factors, for example, sex, race and age. Weight, decreased liquid and calcium utilization, expanded oxalate, sodium and high protein intake are viewed as among the main natural risk factors.[9] Because of its recurrence, urolithiasis is of specific worry for health financial matters. An investigation of the 2009 French information, given from the national coding framework for in-clinic stays and surgico-drug management, utilizing the term 'urolithiasis' uncovered an all out expense of >168 million €.10.

Lotan et al, inspected treatment techniques for renal colic in the Emergency Room in 10 nations in Europe and the USA. The expenses went from $80 to $750 (American dollars).[11]The best extent of the all out expense was identified with radiological examinations in the Emergency Room (40.5%), trailed by treatment costs (19.7%). Consequently, booking the room for treatment of the illness is of most extreme significance in diminishing the resulting costs after confirmation of case of urolithiasis.[12]

The utility of the CT has further enhances in the last decade as it no more just a diagnostic tool. It has successfully helped the healthcare provider to attenuate the composition of the renal stone. This composition of renal stone helps to predict stone size as it was seen that a stone made up of uric acid has lower attenuation (200-400HU) while a stone with high composition of the oxalate and calcium has large attenuation (>1000HU). ESWL can only be successful if it comply to the stone composition and its hardness. NCCT can be helpful in prior determination of the stone attenuation so that failure rate of the ESWL could be reduced.[13]

Recently, a study which is carried out with the objective of determination of success rate of ESWL by taking HU measurement in upper urinary calculi as standard. This study categorized cases in two group (A<750HU and B>750HU), It was further evaluated that there was no significant difference for size of stone in the both groups at the start of treatment viz. 1.51cm group A, group B was 1.59 (p 0.5346). After the ESWL, the stone was completely cleared in group A, but only 15% in other group got their stone cleared(p<0.001). HU measurement in the stone free group was (514.10 versus 970.36 HU, respectively, p<0.0001). Conclusively, it can be drawn that HU value ≥750HU is a good predictor for the bad outcome and low clearance of kidney stone.[14]

In another study on the same pattern which included 60 patients with stone size of ≤20mm size, subjected for ESWL. NCCT was used for the determination of stone density presented by HU measurement. After a two week follow up of the patients, X ray was done to assess the stone clearance. Chemical stone analysis kit was used later on to assess the removed stone composition. Furthermore, the study has calculated that 93% cases has complete stone cleanse97% success of ESWL was seen in stone size <15cm while lesser in larger stone size. They have concluded that for >1000HU stone a higher shock waves are required for the complete clearance. 29% cases has calcium oxalate stone while rest 20% has the other formalities of the stone. As the density of the stone is estimated it was observed that Calcium oxalate was most dense (902.73±425.23 HU) and uric acid stones lowest (364.00±115.17). ESWL wave have similar intensity of wave irrespective of the stone density. But it is important to mention that in order to give ESWL in any case with urinary stone, proper NCCT should be done to determine the actual intensity of wave to clear stone.[15]

In 2014, an examination was performed to assess the utility of the Hounsfield Unit (HU) values as a prescient factor of extracorporeal shock wave lithotripsy result for ureteral and renal stones. A review study was performed to quantify stone HU esteems in 260 patients who went through extracorporeal stun wave lithotripsy (ESWL) for singular renal and ureteral stones from July 2007 to January 2012. Stone volume, area, skin-to-stone distance, stone HU esteems, and stone synthesis were evaluated. Accomplishment of ESWL was characterized as: (1) being free stone or (2) remaining stone parts 815 HU (P <0.0265). HU of calcium oxalate and calcium phosphate stones were higher than those of uric corrosive stones, yet the investigation couldn't separate between calcium oxalate monohydrate and calcium oxalate dehydrate stones. Assessment of stone HU esteems before ESWL can anticipate treatment result and help in the improvement of treatment systems.[16]

In current study diagnostic accuracy was 92.50%, these results are supported by a study in 2013 which has calculated the same diagnostic accuracy. Hence, it is stated that if there is stone size and density is >934 HUs and SSD >99mm, case may be induced with higher waves of SW and so as of ET.

In 2012, another study was done on the same pattern.In this study the stone density was 970HU and clearance was considered at a size of stone of <4mm on CT. At this cute of the sensitive (100%) and specific (81%) point on the receiver-operating characteristic curve. 97% cases who have stone density <970HU were stone free after the session of the ESWL. So it could be stated that stone density calculation by using NCCT is necessary so that ESWL can be performed on the right patients. This can also help to take decision about the number of session required for a case with urinary stone to be stone free.

CONCLUSION

So, through findings of this study it is concluded that predictive accuracy of HU <934 is very good in predicting the stone clearance in renal calculi with ESWL. So, in future pre-procedural HU evaluation can help to select the best therapeutic option.

Author's Contribution:

Concept & Design of Study:	Zeeshan Shaukat
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