A Retrospective Analysis of Effect of Hounsfield Unit of Ureteric Calculus on Outcome of Ureteroscopic Lithotripsy

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ABSTRACT

BACKGROUND

This study was conducted to check whether computer tomography (CT) parameter Hounsfield Unit has any bearing on outcome of ureteroscopic pneumatic lithotripsy and as to whether it can predict success rate of ureteroscopic lithotripsy in the management of ureteric calculus. CT Hounsfield Unit tells us about hardness of stone, and it is primarily important in non-invasive management of ureteric and renal calculus such as extracorporeal shock wave lithotripsy (ESWL).

METHODS

We retrospectively reviewed records of 420 patients who underwent URSL from January 2016 to January 2020. A total of 186 patients of ureteric calculus did undergo CT in pre-operative evaluation for stone. Data of those patients was taken for study. Intra op clearance of calculus was decided by ureteroscopy finding on the table. All complications and difficulties of the procedure were documented.

RESULTS

We analysed the correlation between the outcome of the URSL and Hounsfield unit in finding the position of the stone and size of the stone. Out of 186 study participants, 111 (59.6 %) patients needed a single procedure for stone clearance whereas 75 (40.4 %) needed multiple procedures for clearance. Out of 186, 22 had HU < 500, 112 had HU 501 - 1000, 52 had HU > 1000. The majority of patients had HU between 501 - 1000HU. Complete clearance was seen in 63.6 % of < 500 HU patients, 62.5 % of 501 - 1000 HU patients and 55.7 % of > 1000 HU patients. This difference in clearance was statistically not significant. Similarly, the rate of complication when compared among the three groups doesn't show a statistically significant difference (P value 0.293). The requirement of repeat procedure was maximum in > 1000 HU patients but the difference between the three groups was not statistically significant. Stone migration rate was found to be more in > 1000 HU stones (80.76 %) and this was statistically significant.

CONCLUSIONS

To conclude CT Hounsfield Unit's utility in predicting the stone-free rate and complication rate doesn't show significant bearing in patient undergoing URSL procedure.

KEYWORDS

CT, Hounsfield Unit, URSL, Stone Free Rate, Stone Density, Complication

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BACKGROUND

Helical non-contrast computed tomography (CT) is the gold standard investigation in urological diagnostic armamentarium. Specificity and sensitivity are of CT 94 - 96 % and 96 - 100 % respectively. Hounsfield units (HU) obtained from non-contrast CT is measure of density of stone and it gives idea of probable composition and hardness of structure.[1] Sir Godfrey Newbold Hounsfield first introduced radiodensity scale by quantifying amount of x-ray absorbed or pass through substance. Each CT image is composition of pixel ranging from black to grey to white black correspond to value 0 and white value 256, grey has in-between value. This value essentially means how much x-ray can pass through the structure and that is expressed in HU, which essentially means opacity of material. Water has density, fat has negative density and bone has positive density, anything between it is shade of grey and there are 256 shades which are not distinguishable by naked eyes.[2] HU can also diagnose stone hardness, composition and give idea about appropriate treatment modality. There are many predictive models which tell us about possible outcome, success, and difficulty of procedure such as patients with diabetes mellitus (DM), hypertension (HTN), body mass index, renal anatomy such as bifid system, malrotated kidney, ectopic kidney, variation in calyceal orientation etc. size of stone, number and orientation of stone and position of stone.[3]

Various modalities of treatment for management of ureteric calculus are available such as pneumatic lithotripsy, light amplification by stimulated emission of radiation (LASER) lithotripsy and ESWL. Outcome of ESWL depends on HU. Stone hardness is not particularly deciding criteria in URSL but it definitely has some impact on timing of surgery and completeness of procedure. Among these, URSL is most commonly used by most of the urologist for the very fact that it’s less expensive. Patient acceptance for procedure is good, also stone clearance rate of the URSL is equally as good as ESWL. Stones > 1000 HU are difficult to treat or poor stone clearance by ESWL is seen. LASER which is the latest modality of treatment, is certainly expensive and not widely available. Not all groups of patients will be able to afford it. So URSL is still the most commonly used method for ureteric calculus management.

Established concept about stone HU is that, stone more than 1000HU is hard stone and less amenable to ESWL procedure as hardness makes it resistant to fragmentation and less stone clearance. Only one major study talks about relation between URSL and HU of stone in management of ureteric calculus and it shows there is no relation between outcome of URSL and HU of stone.[4]

Objectives

This study was conducted to find out if there is any correlation between density of stone and outcome of URSL using pneumatic lithotripter. The outcome of procedure in view of stone free rate, complication, need of repeat / multiple procedure and stone migration were compared.

METHODS

In our study, we have retrospectively analysed the results of ureteroscopic lithotripsy for ureteral stones with respect to the stone density as determined by the pre-operative non-contrast CT scan of kidneys, ureters and bladder (KUB) region. We have included all the patients with ureteral stones who have undergone pre-operative non-contrast CT scan of KUB region in our study. The study period was from January 2016 to January 2020. We analysed 186 patients. We have included only those patients of ureteric stones who have undergone pre-operative non-contrast CT scan of KUB region. The exclusion criteria were history of ureteral stricture, single kidney and acute pyelonephritis.

All patients were subjected to 64-slice non-contrast CT. The number, size, location and the Hounsfield units of stones were recorded. Complete blood count, renal function test, urine routine and culture were done for all patients admitted, as per institute protocol. All the patients were submitted for ureteroscopic lithotripsy using 8 / 9.8F Richard Wolf semi-rigid ureteroscope. Stone fragmentation was done by using pneumatic lithotripter with a 1 mm probe. Fragmentation was considered as complete if all the fragments were less than 2 mm in size as determined visually comparing the sizes of the fragments with the tip of the lithotripsy probe. Some fragments were removed with basket and later ureteric double J stent was placed in those cases where fragmentation was incomplete or procedure was met with some per-operative complications or when significant mucosal injury as evident by bleeding of the ureteric mucosa was noted. Those cases where the mucosal injury or mucosal oedema was not significant, stenting was dispensed. All these procedures were done under fluoroscopic guidance to get the assistance for ureteric stenting, proximal migration of stone fragments and to get information about the incompletely fragmented stones. Patients in whom complete fragmentation was not possible in the first sitting, ureteric stenting was done and post-operative x-ray was done to check for residual calculus. In patients with residual calculus, second procedure of ureteroscopic lithotripsy was done after 2 to 6 weeks’ time.

In our study, we have retrospectively analysed the various outcomes of the ureteroscopic lithotripsy procedure such as stone clearance rate, stone migration rate, need of procedure etc. in relation to the stone density as determined by the Hounsfield Units of the ureteric stones by pre-operative non-contrast CT scan of KUB region. We have categorised these patients into three groups, based upon the HU values. Group A less than 500 HU, group B 501 to 1000 HU and, group C More than 1000 HU.

Statistical Analysis

All the data was entered into Microsoft -Excel and statistical analysis done by using Statistical Package for the Social Sciences (SPSS) Version 19. For categorical variables, the values were expressed as numbers and percentages, and to test the association between the two groups, the chi-square test was used. All the tests having P value less than 0.05 were considered statistically significant.

RESULTS

Total 186 patients who had CT scan for ureteric calculus and planned for URSL were the study population, of which 137 were males and 49 females. Mean age group of study population was 41.8 ± 14 yrs. 22 (11.8 %) patients had stone of < 500 HU, 112 (60.2 %) had stone of 501 - 1000 HU, and 52 patients had stones of > 1001 HU. Average stone size of study population was 10.52 (3.25) mm. Out of 186, 111 (59.6 %) patients needed single procedure for stone clearance whereas, 75 (40.4 %) needed multiple procedures for clearance. Patients in group A showed 14 (63.6 %), group B showed 70 (62.5 %), and group C showed 29 (55.7 %) stone clearance rate. This difference in stone clearance is statistically not significant with p value of 0.683 (> 0.05). Rate of complication in group A was 5 (22.72 %), group B was 30 (26.72 %), and in group C was 30 (38.46 %). This difference in rate of complication is high in group C that is > 1001 HU stones but difference among groups was not statistically significant (P-value 0.236). Many patients needed repeat procedure in form of either percutaneous nephrolithotomy (PCNL) or re URSL. Group A only 2 (0.09 %) was re procedure rate, group B showed 35 (31.2 %) and group C 18 (34.61 %) showed with requirement of another procedure for stone clearance. Group B showed maximum requirement for repetition of procedure but difference was not statistically significant and P-value was 0.056. Total of 39 (21 %) patients needed PCNL as second procedure and majority of them belonged to group C (> 1001 HU). Stone migration was highest among > 1001 HU (group C) showing 16 (30.7 %) compare to other groups this was statistically significant high rate of migration with P value 0.024. Out of 186, 60 patients had fever in post-operative period and there was no statistically significant difference in rate of fever among all three groups. Total 171 (91.9 %) patients were stented so majority of patients required stents.

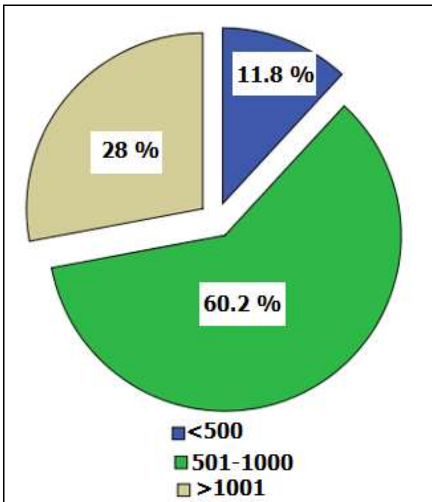

Figure 1. Percentage of Patients with HU Range

HU vs. Clearance		Clearance Complete Count	Clearance Partial Count	P Value - 0.683 (> 0.05)
Range	< 500	14 (63.6 %)	8	
	501 - 1000	70 (62.5 %)	42	
	> 1001	29 (55.7 %)	23	

Table 1. Comparison of HU Range and Clearance of Stone

HU vs. Complication		Complication Absent Count	Complication Present Count	P Value - 0.236 (> 0.05)
Range	< 500	17 (77.27 %)	5 (22.72 %)	
	501 - 1000	82 (73.21)	30 (26.78 %)	
	> 1001	32 (61.53 %)	20 (38.46 %)	

Table 2. Comparison of HU and Complication

HU vs. RE Procedure		Reprocedure Not Done Count	Reprocedure Done Count	P Value - 0.056 (> 0.05)
Range	< 500	20	2 (0.09 %)	
	501 - 1000	67	35 (31.2 %)	
	> 1001	34	18 (34.61 %)	

Table 3. Comparison of HU Range and Need of Re Procedure

HU vs. Stone Migration		Migration 0 Count	Migration 1 Count	P Value - 0.024 (< 0.05)
Range	< 500	21	1 (0.045)	
	501 - 1000	92	20 (17.85)	
	> 1001	36	16 (30.7 %)	

Table 4. Comparison of HU Range and Stone Migration

HU vs. PO Fever		Fever 0 Count	Fever 1 Count	P Value - 0.187 (> 0.05)
Range	< 500	16	6	
	501 - 1000	80	32	
	> 1001	30	22	

Table 5. Comparison of HU Range and Post OP Fever

DISCUSSION

Non-contrast computed tomography (NCCT) is time tested standard of care imaging technique in the diagnosisof urolithiasis. NCCT have 96 % sensitivity, 99 % specificity and 98 % accuracy.[4] NCCT also give idea about stone burden, and orientation of stone which help in planning of surgery and giving fair idea about outcome of surgery.

Knowing Hounsfield unit of stone on NCCT has varied implication such as, determining composition of stone, determining density of stone, outcome of ESWL largely depend on HU of stone, by knowing HU of stone we can decide which modality of energy can be used in PCNL (LASER / Pneumatic).[1]

Stone density also predict stone composition and different stones have different HU. There are some in vitro studies done to establish relationship between stone composition and HU. Each type of stone has distinct value of HU, but majority of stones are complex.[5-7]

Several secondary signs also determine the outcome of surgery such as periureteric oedema, hydronephrosis, perinephric oedema etc. Per ureteric oedema is annular shadow of 20 – 40 hu present around the ureter at the site of stone it is graded as 0 = absent, 1 = < 2 mm shadow, grade 3 = > 4 mm shadow and grade 2 = in between 1 and 3. (4) Perinephric oedema is fluid in perinephric space grade 0 = absent, grade 1 = ½ small packets each 1 cm. 3 = large collection more than 1 cm. grade 2 between 1 and 3.

In study conducted by Mostafavi MR et al.[7] following are values of each type of stones, these values were.

Stone Composition	HU
Uric acid stones	112 - 436 HU
Struvite stones	510 - 681 HU
Cysteine stone	994 -1180 HU
Calcium phosphate	1252 - 1640 HU
Calcium oxalate dehydrate	1813 HU
Calcium oxalate monohydrate	1743 - 2857 HU

Table 6. Stone Composition and Average Stone Density in HU

Abdel-Halim RE et al.[8] conducted analytical study, they classified stones on the basis of basic composition such as urate, phosphate, oxalate but problem with the study was that these stones were always present in composition form, so they did not give much idea of exact density.

Stone Content	HU
Urate	513 ± 197 HU
Phosphate	1660 ± 292 HU
Oxalate	1684 ± 290 HU

Table 7. Individual Stone Component HU Range

Approximately 80 % of the stones in the urinary tract were formed by two or more different combinations of crystal phase.[9]

But in vivo, CT analysis for predicting stone composition doesn't always correlate with exact stone composition. The collimation size of CT scanner and size of stone dose affect the HU of stone. So, stone composition will differ from absolute HU on CT scanner but ability to differentiate different composition will decrease with increasing collimation size. Management of renal calculus has come long way. It started with open surgery such as pyelolithotomy later on percutaneous nephrolithotomy, percutaneous lithotripsy using laser or pneumatic surgery, and ESWL.

ESWL though has some advantage like non-invasive procedure and day care procedure but when compared to stone clearance rate ureteroscopic lithotripsy is better than ESWL.[10]

Over last two decades, rate of complication has decreased significantly due to improved visualisation and availability of smaller, flexible and better ureteroscopes which has lower complication rates, URSL complication rates have come down equal to ESWL.[4] Various factors predict the outcome of URSL such as stone size, position of stone, surgical instruments viability and surgeon's expertise. In general, stones which are larger in size and upper ureter associated have lower clearance rate and higher complication rate.[4]

Effect of CT HU on outcome of URSL has not been extensively studied, in our literature search, we found single study by Kim et al.[4] in which they retrospectively studied 237 patients of ureteric calculus, who had CT before URSL to see effectiveness of various CT parameters on URSL outcome.

They found HU which reflects stones' composition and hardness has direct association with ESWL outcome but in case of URSL, success doesn't correlate with HU. It's hypothesised that total energy delivered to break the stone is higher in ESWL. That is the reason stones with higher HU are not good candidates for ESWL.

In our study we have compared HU with stone free rate, complication and need of re procedure. We didn't find statistically significant difference in < 1000 HU and > 1000 HU stones. Only one parameter which showed significant difference was stone retropulsion / migration which is higher for > 1000 HU stones.

But there are other parameters which we didn't study such as time needed for fragmentation for stone > 1000 HU compare to < 1000 HU stone, as prolong surgery itself is risk factor for complication. Also, the settings of pneumatic lithotripter were same for all stones and that was a reason that hard stones didn't do well in our study.

CONCLUSIONS

CT Hounsfield Unit's utility in predicting the stone-free rate and complication rate doesn't show significant bearing in patient undergoing URSL procedure. But at the same time, it will help us in predicting the difficulty of procedure and chances of complication.

Limitations of the Study

We haven't included secondary signs in our study which also have impact on outcome of surgery in view of stone clearance and complication. Stone size was not included in our study. Position of stone itself has impact on outcome of procedure.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
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