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Radiology Section

JSS CT Scoring System for Management of Ureteric Calculi

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ABSTRACT

Introduction: Urolithiasis is a worldwide health issue which costs significant financial and man power burden. Dilemma exists among treating physicians in choosing appropriate line of management.

Aim: To evolve an objective scoring system based on CT parameters in management of ureteric calculus.

Materials and Methods: A total of 180 patients suffering from ureteric calculus and who underwent CT scan during January 2018 to February 2019 in Department of Radiology, JSS Medical College, Mysore, Karnataka, India, were included in this prospective study. Each parameter like size of calculus, site, peri-ureteric rim, ureteric dilatation just proximal to site of obstruction, renal parenchymal attenuation and peri-nephric fat stranding were scored on a point scale. A cut-off point of 13 of the total score was arrived based on statistics and was used in choosing the line of management. The predictions were correlated with actual successful line of management employed by the urologists in line with American Urological Association (AUA) guidelines.

Results: Out of 180 patients with ureteric calculus, most common site of ureteric calculus was upper ureter (43.3%) followed by Vesico Ureteric Junction (VUJ) (36.7%). Mean width of calculi which were treated by Medical Expulsive Therapy (MET) was 3.68 mm, whereas calculi with width of more than 6.0 mm were treated by interventional procedures. Nearly, 76% of patients with peri-nephric fat stranding and 92.6% with positive peri-ureteric rim sign underwent interventional procedures. Mean attenuation of the affected kidney was 30.93 Hounsfield Units (HU) and mean attenuation of unaffected kidney was 36 HU. Nearly, 90.48% of patients with scores equal or above 13 underwent interventional procedures and 83.33% of patients with scores below 13 were treated by MET.

Conclusion: The JSS CT scoring system is a unique point based system to objectively choose the suitable line of treatment in patients with ureteric calculus.

Keywords: Computed tomography parameters, Objective score, Urolithiasis

INTRODUCTION

Urolithiasis is prevalent across vast and varied sections of world population. In the latter part of the 20th century, advancements in clinical and diagnostic procedures as well as changes in food habits and environmental conditions, probably led to increase in prevalence and incidence of urinary tract stones, in Western countries. No exact data exists about the epidemiology of renal stones in Indian context. Variety of factors like change in dietary habits, climatic variation, obesity, increased waist circumference, abnormal BMI are known to affect the incidence of renal stone formation [1]. According to the survey conducted by National Health and Nutrition Examination as of 2012, 10.6% of men and 7.1% of women in the United States were affected by renal stone disease, compared to just 6.3% of men and 4.1% of women that were affected in 1994. Close to 2 million people were diagnosed as cases of urolithiasis, resulting in than 6 lakhs emergency admissions and more than 177,000 hospitalisations, costing more than 2 billion dollars expenditures [2]. As the prevalence of urolithiasis is increasing the treatment cost is also increasing inspite of emerging minimally invasive treatment options.

Ultrasound is the modality of choice for preliminary evaluation as well as follow-up. Computed Tomography (CT) is considered as the gold standard in assessing the exact site, size and characterisation of calculus as well as determining secondary signs of obstruction. These factors help in predicting the outcome and to choose between invasive procedures and Medical Expulsive Treatment (MET). MET involves administration of drugs like nifedipine and alpha blockers which facilitate and accelerate the spontaneous passage of ureteric stones as well as stone fragments generated with Shock Wave Lithotripsy (SWL) [3,4]. When removal becomes necessary SWL and ureteroscopy based procedures remains the two primary treatment modalities for the management of symptomatic ureteric calculi. Other treatments include percutaneous antegrade ureteroscopy, laparoscopic and open surgical ureterolithotomy. Open stone surgeries are considered only when all the options of minimally invasive surgeries are not feasible. Blind basketing procedures are obsolete with emerging fluoroscopic guided procedures. World over health insurance sectors and government organisations have started monitoring and discouraging unwanted invasive procedures to bring down costs and to reduce morbidity. Many professional bodies such as American Urological Association (AUA) have issued periodic guidelines for treating ureteric stones. But many of the guidelines are still prone for subjective interpretations. In such a scenario, it is handy to have a robust objective scoring system which can be used as a guideline in management of ureteral calculi.

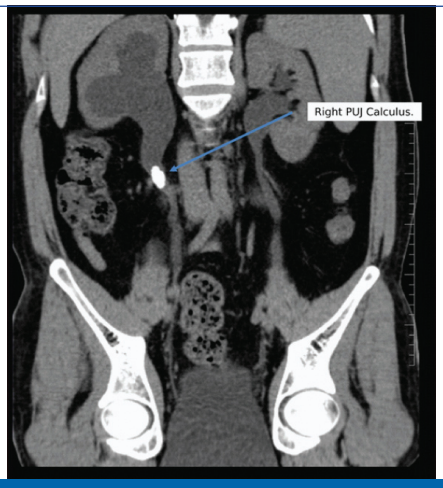
MATERIALS AND METHODS

A prospective study was carried out in which a total of 180 patients who underwent plain CT scan of KUB region (none of the patients were subjected to CT scan for the purpose of study) and treated for ureteral stones in the JSS Medical College Hospital, Mysore, Karnataka, India, during January 2018 to February 2019, were included in the study with relevant approval by the institutional review board. Inclusion criteria consisted of consecutive patients suffering from ureteral stones who have undergone pre-treatment non-contrast computed axial tomography of KUB region (CT-KUB). Patients with anatomical abnormalities, urinary tract infection, renal failure and patients who have undergone previous procedures of uro-genital system were excluded from the study. Chronic ureteric obstruction with thinned out renal parenchyma were also not included in the study.

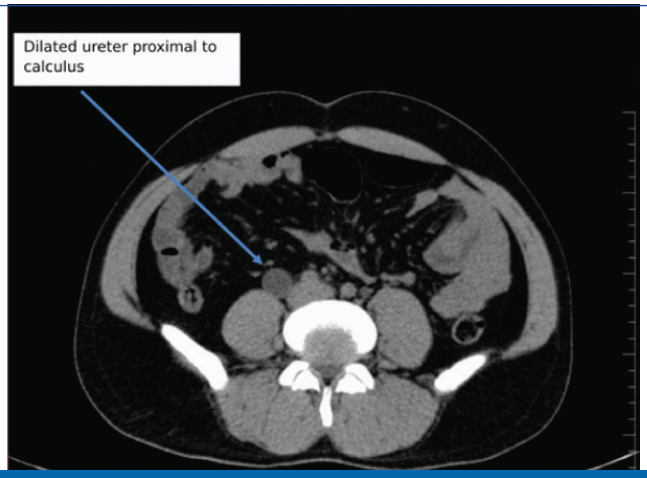
Ingenuity 128 slice CT Philips scanner was utilised for the study. Axial volume data was obtained from dome of diaphragm to pubic symphysis with collimation of 0.625 mm and was reconstructed to 3 mm slices. Relevant coronal, sagittal and free hand modified

coronal images were reconstructed and reviewed in abdominal and bone window settings.

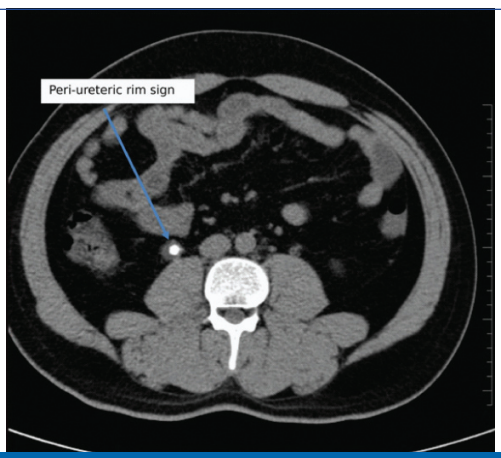
The JSS CT scoring system is a proposed, objective, point based system to predict the most suitable treatment option for patients suffering with ureteric calculus based on pre-operative characteristics of plain CT-KUB, such as: 1) Size of the stone; 2) Location [Table/Fig-1]; 3) Ureteric diameter just proximal to the site of obstruction [Table/Fig-2]; 4) Thickness of peri-ureteric rim [Table/Fig-3]; 5) Renal parenchymal attenuation [Table/Fig-4]; and 6) Presence of peri-nephric fat stranding [Table/Fig-5]. Each feature was graded on point scale as described in [Table/Fig-6]. In cases with multiple calculi, the stone with the highest score was considered. All scores were assigned by two radiologists with minimum three years of experience and mean score was considered for all calculations. The point system was developed after thorough review of literature and in depth retrospective analysis of HIS (Hospital information system) data in our institute.



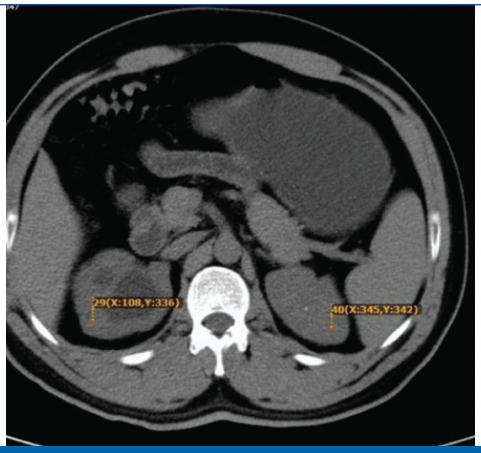
[Table/Fig-1]: Coronal reformatted image showing right PUJ calculus.



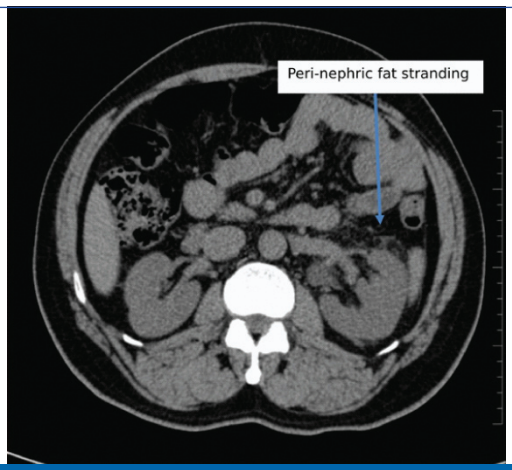
[Table/Fig-2]: Dilated ureter proximal to level of obstruction.



[Table/Fig-3]: Peri-ureteric rim.



[Table/Fig-4]: Attenuation values of the kidneys.



[Table/Fig-5]: Peri-nephric fat stranding.

STATISTICAL ANALYSIS

Statistical analysis to construct the JSS CT scoring system was performed using SPSS 21.0 software. Data was presented as average±standard deviation or frequency (percentage of total). Independent t-test and chi-square tests were used for statistical analysis. The p-value of <0.050 was considered significant.

Based on this, ROC curve was constructed and test result variable curve were introduced to calculate Youden's index. It was maximum at point between 12.5 to 13.5, hence the cut-off of 13.0 was selected. The predicted line of management was correlated with actual line of successful treatment employed by the urologist according to AUA guidelines [5,6]. The urologists were blinded from the scoring system details. The sensitivity, specificity, NPV and PPV of the cut-off point were calculated.

RESULTS

Majority of the patients were in the age group of 36-45 years (38.3%), with mean age of 41 years. There was male preponderance with 129 patients (71.7%) while female patients constituted 51 (28.3%). Both sides were equally affected left 90 (50%) and right 90 (50%) [Table/Fig-7].

Mean width of calculus was 5.27 mm and median of 4.0 mm with a standard deviation of 2.69. In our study the mean width of calculus which underwent MET was 3.68 mm whereas, calculi with width of more than 6.0mm underwent interventional procedures [Table/Fig-8]. Mean diameter of dilated ureter, just proximal to the calculus was 6.82 and median was 5.50 with standard deviation of 3.53 mm.

Majority of the calculi were located in the upper third of ureter i.e., 78 (43.3%) while second most common site was VUJ 66 (36.7%) followed by lower third of ureter 24 (13.3%), mid ureter 12 (6.7%) and PUJ 9 (5.0%). In our study 54.5% of patients with VUJ calculus had successful stone expulsion after MET, while only 37.5% of patients with lower ureteric calculus and 50% of patients with mid ureteric calculus

Features	Parameters	Points
Breadth of calculus	</=3 mm	2
	4-6 mm	4
	7-9 mm	6
	10-12 mm	8
	13-15 mm	5
	>/=16 mm	10
Diameter of dilated ureter just proximal to site of obstruction	</=3 mm	1
	4-6 mm	2
	7-9 mm	3
	10-12 mm	4
	13-15 mm	5
	>/=16 mm	6
Location of the calculus	Vesico-ureteric junction juncti	1
	Lower ureter	2
	Mid ureter	3
	Upper ureter	4
	Pelvi-ureteric junction	5
Peri-ureteral rim thickness	</=2.5 mm	1
	2.6-3.0 mm	2
	3.1-3.5 mm	3
	>/=3.6 mm	4
Attenuation of renal parenchyma	>/=38 HU	1
	35-37 HU	2
	32-34 HU	3
	29-31 HU	4
	</=26 HU	5
Peri-nephric fat stranding	Absent	0
	Present	1

[Table/Fig-6]: Point scale of all features affecting the outcome.

		Count	Column N %
Age category	<25	15	8.3%
	26-35	48	26.7%
	36-45	69	38.3%
	46-55	27	15.0%
	>56	21	11.7%
Sex	Female	51	28.3%
	Male	129	71.7%
Side	Left	90	50.0%
	Right	90	50.0%

[Table/Fig-7]: Age, sex and side.

	Invasive Interventional		MET		p
	Mean	SD	Mean	SD	
Peri-ureteral rim thickness in mm	2.98	0.66	2.20	0.00	
Width of stone in mm	6.00	2.94	3.68	0.82	0.001
Size of dilated ureter mm	8.04	3.65	4.25	0.99	
Attenuation of kidney at mid pole mm	30.40	3.89	32.05	3.01	0.1

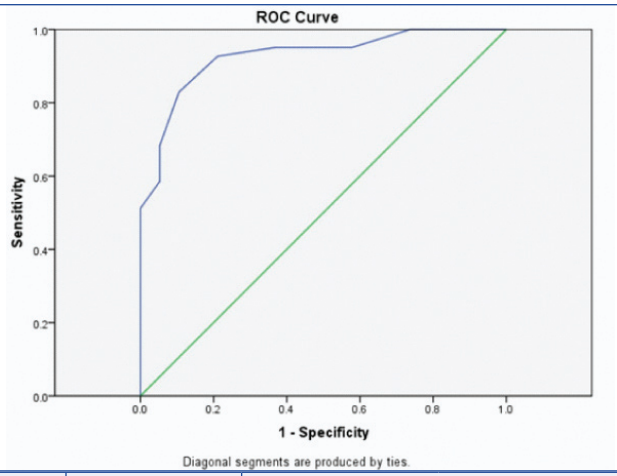
[Table/Fig-8]: Factors affecting the outcome.

were treated by MET. (All patients with PUJ calculus and 92.3% of patients with upper ureteric calculus were treated with interventional procedures. Peri-nephric oedema was present in 87 cases (48.3%) Peri-ureteral rim sign was present in 81 cases (45.0%) [Table/Fig-9].

		Invasive intervention		MET		
		Count	row %	Count	row %	p
Peri-nephric oedema	No	57	61.3	36	38.7	0.2
	Yes	66	75.9	21	24.1	
Peri-ureteral rim	No	48	48.5	51	51.5	<0.0001
	Yes	75	92.6	6	7.4	
Site	PUJ	9	100.0	0	.0	<0.0001
	Upper	72	92.3	6	7.7	
	Mid	6	50.0	6	50.0	
	Lower	15	62.5	9	37.5	
	VUJ	30	45.4	36	54.5	

[Table/Fig-9]: Factors affecting the line of management.

The AUC (Area under the ROC curve) is a measure of how well a parameter can distinguish between two groups. In our study the scoring system was able to differentiate the patients in terms of line of management i.e., whether the patient needs medical management or interventional procedure. The area under curve for predicting need for surgical intervention using JSS CT scoring system was 0.927 with 95% confidence interval and statistically significant with p-value of <0.001 [Table/Fig-10].



Area	p	95% Confidence Interval	
		Lower Bound	Upper Bound
0.927	<0.0001	0.860	0.994

[Table/Fig-10]: AUC for predicting surgical intervention using JSS scoring system.

Out of the 180 patients, 123 patients (68.3%) were treated with interventional procedures and 57 patients (31.7%) underwent MET. Lowest total score in the study was 7 and highest was 30. Most of the patients with score of more than 13 underwent invasive stone extraction with only few exceptions. Fourteen patients with scores equal to or less than 13 underwent interventional procedures, out which 12 had a score of 13. Scoring system helped us in predicting the line of management without any subjective bias by the treating urologist [Table/Fig-11].

JSS score	Count	Column N %	MET	INTERVENTION
7-9	15	8.30	15	0
10-12	39	21.60	30	9
13-15	51	28.33	9	42
16-18	30	16.60	3	27
19-21	21	11.60	0	21
22-24	15	8.30	0	15
>/=25	9	5.00	0	9

[Table/Fig-11]: Point scale and outcome.

The sensitivity of the scoring system was 82.93%, specificity of 89.47%, and diagnostic accuracy was 85% [Table/Fig-12].

Parameter	Estimate	Lower-Upper 95% CIs
Sensitivity	82.93%	(68.7, 91.5)
Specificity	89.47%	(68.6, 97.1)
Positive Predictive Value	94.44%	(81.9, 98.5)
Negative Predictive Value	70.83%	(50.8, 85.1)
Diagnostic Accuracy	85%	(73.9, 91.9)

[Table/Fig-12]: Measures of performance of JSS scoring system.

DISCUSSION

Direct visualisation of ureteric calculus is considered as the diagnostic sign for obstructive urolithiasis [7-12]. Plain CT scan is being used predominantly for visualisation of calculus and locating the site of calculus. In our study, apart from direct visualisation of ureteric calculus number of other accompanying features of obstructive urolithiasis was included like location of the calculus, size of dilated ureter, peri-nephric rim and attenuation value of kidney in predicting the line of management. Calculus size, in particular width of the calculus, plays crucial role in choosing line of management. Hence width of calculus was given more weightage than all other parameters. Similarly diameter of the dilated ureter, just proximal to the level of obstructing calculus was given scores as mentioned below. Degree of obstruction directly reflects the symptoms experienced by the patient and hence plays an important role in management of the ureteric calculus. Location was another factor which greatly influences the line of management. While distal stones tend to be easily treated with MET, stones in the proximal and mid ureter may require surgical intervention. Peri-ureteric rim thickness (thickness of soft tissue at the level of calculus, due to inflammation), attenuation of renal parenchyma (average of three measurements at upper, mid and lower poles of the affected kidney) and peri-nephric stranding are indirect signs of acute ureteral obstruction and hence are given due importance in the scoring system. Attenuation values of the stone are important if SWL is being considered, but do not impact the choice of management vis a vis MET v/s intervention. As this study was not evaluating different methods of interventions, attenuation values of the calculi were not included in this scoring system. The line of management of ureteric calculus is based upon number of variables acting simultaneously rather than individually. Hence the proposed JSS CT scoring system which takes into account all these factors attempts to enhance the sensitivity and specificity in predicting the line of management.

Similar variables were used in other studies carried out by Kawashima A et al., Coll DM et al., and Goldman SM et al., as specific signs of obstructive urolithiasis [13-15]. Study by Ng CF et al., had introduced a scoring system using stone volume, attenuation and skin stone distance for upper ureteric calculus in predicting the outcome of SWL [16]. Study by Molina WR et al., proposed STONE scoring system based on (S)ize of the stone, (T)opography or location, degree of (O)bstruction of the urinary system, (N)umber of stones, and (E)valuation of Hounsfield units in predicting the degree of stone free rate by ureteroscopy guided procedures [7]. But none of the studies were conducted to predict the line of management as MET v/s interventional procedures.

MET is the initial treatment modality in selected obstructive urolithiasis patients, as it may facilitate passage of ureteral stones [17,18]. JSS CT scoring system thus enables the treating physician to confidently opt for MET in suitable patients with score less than 13, thus reducing the cost of patient care and bringing down the morbidity associated with interventional ureteral stone management.

Ureteral stones with diameter of less than 7 mm (in the absence of uncontrolled pain, inadequate renal function, clinical evidence of sepsis or peri-nephric urine extravasation) are good candidates for MET and may not require intervention. A study done by Erdodru T et al., found that the degree of obstruction was more directly related to the width rather than the length of the stone and concluded that the width was the critical measurement [19]. Spontaneous passage of ureteral stones with less than 7 mm diameter, without ureteral rim sign, was observed in 67% of patients, while it was only 19% in ureteral stones of more than 7 mm diameter. In another study done by Ueno A et al., spontaneous passage rates of 100%, 93%, 87%, and 78% were observed for stones measuring 1, 2, 3, and 4 mm in width, respectively. The rate of spontaneous passage dropped to 57% for 5 mm stones, 35% for 6mm stones, 28% for 7 mm stones, and 14% for 8 mm stones. No stones exceeding 8 mm in width passed spontaneously [20]. All stones with more than 6 mm width underwent interventional procedures in our study.

In a study done by Papadoukakis S et al., the overall passage rate by MET is 25% for the proximal ureter stone, 45% for the mid ureter stones and 70% for the distal ureter stones, provided that the mean diameter of stone does not exceed 7 mm [21]. The closer the calculus to the VUJ the higher the chances for MET. Similar results were observed in our study also.

Peri-ureteral rim sign is the presence of soft tissue rim around the calculus. This occurs due to oedema and inflammation. Though this sign was not predictive for spontaneous passage of ureteral stones it impacts moving down of stones overtime, reveals a study done by Takahashi N et al., [22].

Attenuation difference between the kidneys, the diameter of dilated proximal ureter and peri-nephric fat stranding are secondary signs of ureteral calculus. These features may be seen in recently passed out ureteric calculus also. Greater the attenuation difference between the kidneys, more is the degree of obstruction [15].

We believe the present study which takes into account all these factors using a point based scoring system is by far the best way to choose the treatment options. The cut-off point of 13 provides a sensitivity of 82.93%, specificity of 89.47% and positive predictive value of 94.44%, which indicates that the scoring system is worthy to be considered in routine clinical practice.

LIMITATION

However, considering the fact that the study was carried out in a single institute, a multi-centric validation study is required to test the robustness of the scoring system. Absolute attenuation values may vary a bit from equipment to equipment and needs standardisation.

CONCLUSION

The JSS CT scoring system is a unique point based system to objectively predict the suitable line of treatment in patients with ureteric calculus. Parameters like stone size, location, proximal ureteric dilatation, ureteric rim thickness, peri-nephric fat stranding and attenuation values of the kidney are relevant factors in predicting the line of management. The JSS CT scoring system provides unbiased objective guideline for employing suitable treatment options for treating ureteral stones.

Abbreviations: MET- Medical Expulsive Therapy; VUJ- Vesico-Ureteric Junction; CT-Computed Tomography; JSS - Jagadguru Shri Shivarathreeshwara.

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