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The Stone Score: A New Preoperative Assessment Tool to Predict Stone Free Rate Following Ureterolithotripsy

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Abstract: ***Background:*** Ureteric stones are a common cause of urinary tract obstruction and can lead to significant morbidity if not managed effectively. Ureteroscopy has become a widely used minimally invasive treatment option for ureteric calculi, offering high success rates with fewer complications. The STONE scoring system, based on radiological features, has been developed to help estimate the complexity of ureteric stones. This quasi-experimental study was designed to assess the STONE score's predictability in stone-free rate on ureterolithotripsy from preoperative imaging features (NCCT of KUB). ***Methods:*** This hospital-based quasi-experimental study took place in the Department of Urology, NIKDU (National Institute of Kidney Disease and Urology), Sher-E-Bangla Nagar, Dhaka, Bangladesh, from January 2020 to June 2020. A total of 30 subjects were included in the study by a purposive sampling technique. Statistical analyses were carried out by using the Statistical Package for Social Sciences version 23.*0*. ***Result:*** In this study of 30 patients (mean age 35.83±12.71 years; 63.33% male), lower STONE scores (5–8) were associated with a 100% stone-free rate and minimal complications, while higher scores showed reduced clearance and more complications. The mean STONE score was significantly lower in stone-free patients (9.39±1.86) versus those with residual stones (12.33±1.03, $p<0.05$). Logistic regression confirmed higher scores significantly reduced stone-free chances (OR 0.448, $p=0.043$), with no significant impact on operative time or hospital stay. ***Conclusion:*** The STONE score is a significant predictor of stone-free status after ureteroscopy, with lower scores (5–8) linked to 100% stone clearance and fewer complications. Stone-free patients had a significantly lower mean score than those with residual stones. Logistic regression confirmed that higher STONE scores reduce the chance of stone clearance, while operative time and hospital stay were not significantly affected. Thus, the STONE score effectively predicts ureteroscopy outcomes.

Keywords: STONE Scoring, Ureterolithotripsy, Ureteroscopy, Predictability.

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INTRODUCTION

Urolithiasis has a prevalence of around 10% in the adult population.[1] The stone that obstructs a patient's ureter originates in the kidney. Ureteric colic occurs as a result of obstruction of the urinary tract by calculi at the narrowest anatomical areas of the ureter: the pelviureteric junction (PUJ), near the pelvic brim at the crossing of the iliac vessels, and the narrowest area, the vesicoureteric junction (VUJ).[2] When the ureter is not otherwise obstructed, the chief determinant of stone passage is the diameter of the stone in its transverse orientation. Next most important is the location of the stone within the ureter at presentation, with a review of the literature demonstrating a 71% chance of passage of a distal ureteral stone versus 22% for proximal stones. Concerning size as a predictor of spontaneous passage, meta-analysis of the available literature (as described in the AUA ureteral stone guidelines) demonstrates a 68% chance of passage for stones 5 mm or smaller, and an estimated 47% chance for stones 6 to 10mm in size.[3]

S.T.O.N.E. score is a proposed system to predict the stone-free status of a patient from preoperative characteristics available on CT-KUB: (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. Higher scores indicate higher complexity and, presumably, lower stone-free rates. Each feature from the CT was graded on a 1-3 point scale. In cases with multiple calculi, the stone with the highest grade for each feature was recorded. All scores were assigned after a consensus of two observers.[4] Many patients have small stones that pass spontaneously; this process can be accelerated with medical expulsive therapy, primarily by a-blockade. The majority of patients who are unsuccessful with a-blockade are treated with minimally invasive procedures such as shock wave lithotripsy (SWL) and ureteroscopy (URS).[5] The need for an invasive intervention and the possibility of complications are investigated with the help of radiologic imaging. The reference standard test in suspected ureteral stone is a nonenhanced abdominopelvic computed tomography (CT) scan.[6] Minimal invasive techniques for management of ureteric calculi include extracorporeal shockwave lithotripsy (ESWL), ureteroscopy (URS), and laparoscopic ureterolithotomy. The choice of the procedure depends on location and characteristics of the stone, patient's preference, as well as associated costs. According to the European Association of Urology 2007, ureteroscopy is an effective therapeutic modality for distal ureteric calculi.[7] Determining whether a patient is an appropriate candidate for URS should be the first step in maximizing stone-free rates. Multiple preoperative predictors have been suggested as tools to improve decision making and to better counsel patients on expected outcomes. A number of different parameters have been used, including stone burden, presence of hydronephrosis, stone location, number of stones, computed tomography (CT) stone attenuation, age, sex, preoperative stenting, and surgeon's experience. The most influential parameters are consistently stone burden and location.[5] Many studies have evaluated the factors affecting the success rate of these procedures. Preoperative scores and nomograms have been developed and are available to predict the stone-free rate (SFR) with varying degrees of accuracy. For f-URS, four scores have been developed. Two of these have been compared and validated in different cohorts: the Resolu Unsal Stone Score (RUSS) and modified Seoul National University Renal Stone Complexity (S-ReSC) score. To our knowledge, the other two scores, the S.T.O.N.E score described by Molina *et al.* and lto's nomogram, have not been validated in any other cohorts.[8] The STONE score is a recently derived clinical prediction rule designed to aid clinicians in evaluating the risk of ureteral stone and important alternative diagnoses for patients with suspected nephrolithiasis.

The STONE score is calculated as a weighted sum of 5categorical predictors; the points for each predictor are based on the estimated coefficient from a regression model constructed to predict the presence of a ureteral stone. Patients were classified into low, moderate, and high-score groups with corresponding outcome probabilities of ureteral stone and important alternative diagnoses.[9] This study will be designed to assess the STONE score's predictability in stone-free rate on ureterolithotripsy from preoperative imaging features.

METHODS

This hospital-based quasi-experimental study took place in the Department of Urology, NIKDU (National Institute of Kidney Disease and Urology), Sher-E-Bangla Nagar, Dhaka, Bangladesh, from January 2020 to June 2020. Patients with renal andureteric stone undergoing URS stone removal in the Urology department of the National Institute of Kidney Diseases and Urology were considered as the study population. A total of 30 subjects were included in the study by a purposive sampling technique. The inclusion criteria for this study comprised patients aged 16 years and above, presenting with radio-opaque renal stones measuring between 8 mm and 20 mm in size. Only those who met all three criteria were considered eligible for enrollment in the study. The exclusion criteria for the study included patients with any degree of ureteral stricture distal to the stone, those with radiolucent stones, and cases where ureteric injury occurred during the procedure. Patients meeting any of these conditions were excluded from the study to ensure uniformity in the analysis and outcomes.

All patients underwent thorough evaluations, including history, physical examination, and relevant investigations such as urine analysis, CBC, serum creatinine, coagulation profile, USG KUB, x-ray KUB, and non-contrast CT KUB. X-ray KUB was repeated on the day of surgery. Documented UTIs were treated, and comorbidities were optimized preoperatively. STONE scores were assigned before surgery. Ureteroscopy was performed under spinal anesthesia using an 8 Fr semi-rigid or flexible ureteroscope (Storz FLEX-XC), advanced via a UAS. In lithotomy position, the ureteroscope was guided by a 0.035-inch wire. Stone fragmentation was done using a pneumatic lithoclast, with low-pressure irrigation for visibility, and fragments were extracted using a stone grasper. Statistical analyses were carried out by using the Statistical Package for Social Sciences version 23.0 for Windows (SPSS Inc., Chicago, Illinois, USA). The numerical data were expressed as mean ±SD and were compared via the student's t test. A logistic regression model was applied to evaluate data for stone stone-free rate. P <0.05 was considered statistically significant. The result was presented in tables, figures, and diagrams. The 95 % confidence intervals (CI) were calculated for these values. Ethical clearance for the study was obtained from the ethical committee of the National Institute of Kidney Diseases and Urology, Sher-E-Bangla Nagar, Dhaka, Bangladesh. Written consent was obtained from each subject.

RESULTS

Table 1: Age Distribution (n=30)

Age	frequency	Percentage
16-25	7	23.33%
26-35	10	33.33%
36-45	8	26.67%
46-55	1	3.33%
>56	4	13.34%
Mean	35.83±12.71	
Range	19-59 years	

Table 1 shows that out of 30 patients maximum 33.33% belonged to the age group 26-35 years, followed by 26.67% in the 36-45 years age group. The mean age was 35.83±12.71 years (Age range: 19-59 years). [Table 1]

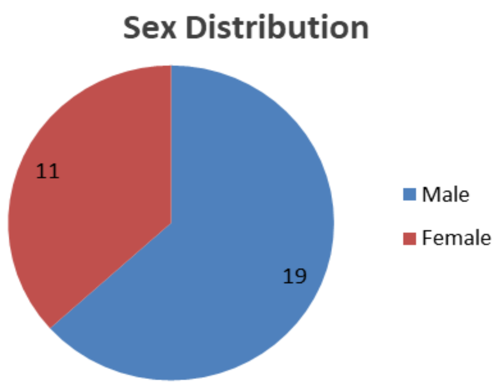

Figure 1: **Sex Distribution (n=30)**

Figure 1 shows that out of 30 patients 19963.33%), patients were male, and 11(36.67%) patients were female. The male-to-female ratio was 1.7:1.

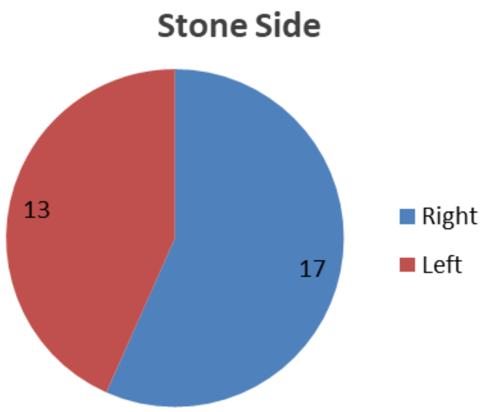

Figure 2: Distribution of Patients by Stone Side (n=30)

Figure 2 shows that 17(56.67%) patients presented with right-sided ureteric stones, whereas 13(43.33%) patients had left-sided ureteric stones.

Table 3: STONE Score in Score in Stone-Free Patients and Patients with Residual Calculi (n=30)

	Stone free	Residual calculi	P value
STONE score (mean±SD)	9.39±1.86	12.33±1.03	0.000125[s]

P-value was calculated by a paired 't' test
[S] Significant

The table shows mean STONE score in stone-free patients is 9.39±1.86 and 12.33±1.03, respectively ($p<0.05$). [Table 3]

Table 4: Patient Distribution, Stone Free Status and Complications According to STONE Scoring System (n=30)

The STONE scoring	Number of patients n (%)	Stone-free patients n (%)	Number of complications	
			1	2
5	2 (6.67%)	2 (100%)	0	0
6	2 (6.67%)	2 (100%)	0	0
7	3 (10%)	3 (100%)	0	0
8	4 (13.33%)	4 (100%)	1	0
9	4 (13.33%)	3 (75%)	0	0
10	6 (20%)	5 (83.33%)	1	0
11	3 (10%)	2 (66.67%)	1	1
12	4 (13.33%)	2 (50%)	1	1
13	2 (6.67%)	1 (50%)	0	1
14	0	0	0	0
15	0	0	0	0

Patients with lower STONE scores (5–8) achieved a 100% stone-free rate with minimal to no complications. As the STONE score increased, the stone-free rate gradually declined, dropping to 50%

for scores 12 and 13. Notably, complications, including one or two events per group, were observed only in patients with scores 8 and above, with the highest complication frequency seen in scores 11 to 13. No patients had scores of 14 or 15 in this cohort. [Table 4]

Table 5: Effect of STONE Scoring System on Stone Free Status, Operative Time, and Length of Stay (n=30)

STONE scoring system	B-coefficient	OR	95% CI	P value
Stone free	-0.80	0.448	0.20–0.97	0.043^{ts}
Operative time	0.109	1.11	0.93–1.34	0.244^{ns}
Length of Hospital stay (days)	-1.24	0.288	0.008–10.08	0.493^{ns}

Binary logistic regression was done to analyze the data.
^{s} = significant

Logistic regression analysis showed an odds ratio (OR) of the STONE score to be 0.448 (P = 0.043), which was significantly associated with stone-free rates. [Table 5]

DISCUSSION

The current study aimed to use the STONE score to predict the stone-free rate in ureteroscopy from preoperative radiological features.[6] According to the results, the STONE score was significantly associated with predicting stone-free rate following ureteroscopy. In our study, the mean age was 35.83±12.71 years (range 19-59years). There were total 19 (63.33%) male and 11 (36.67%) female patients. Male to female ratio was 1.7:1. This is comparable to the findings of Türk *et al.* in the EAU Guidelines on Urolithiasis, which reported that urolithiasis most commonly affects individuals between 30 and 60 years of age and is more prevalent in males, with a male-to-female ratio of approximately 2:1.[10] The mean body mass index (BMI) of the patients in the study was 24.52±3.49. The success rate in our study was 80%. The mean stone size (mm) in this study was 10.93±2.75 mm. The mean STONE score was 9.23±2.35. In our study, we found a 100% stone clearance rate in patients scoring up to a, and then the stone clearance rate gradually declined as the STONE score increased. Patients with scores 12 and 13 had a stone clearance rate of 50%. Patients with stone-free status had a mean STONE score of 9.3911.86, and those with residual calculi were 12.33±1.03 (p<0.05).

Regression binary logistics showed stone-free rate was significantly associated with STONE score, with OR 0.448(95%CI 0.20-0.97), with a p-value of 0.043. This means a single score increase in the STONE scoring system reduces the stone clearance rate by 0.448 times. Lower stone clearance rate with high STONE score may be associated with increased stone size, impacted stone, increased stone number, increased HU, and location. We found no significant association of STONE score with operative time and length of hospital stays (p value was 0.244 and 0.493 respectively). Our findings were similar to the work done by Molina *et al.*[4] They found stone stone-free rate to be correlated to the STONE score and as the score increased, the SFR decreased with a logical regression trend (p<0.001). Score ≤9 points obtain stone free rates >90% and typically fall off by 10%per point thereafter. The stone location is one of the most important factors regarding the stone clearance rate. In our study, we found that proximal ureteral and lower calyceal stone have a lower clearance rate. Bagley DH found success rate for treating proximal ureteral stones with small rigid and flexible ureteroscopes and the holmium laser is well over 90%.[11]

Lower pole renal calculi can also be treated with a success rate of approximately 80%. Stones in mid ureter to the vesico-ureteric junction have a clearance rate of >95%. Impacted stones are also associated with poor stone clearance. They may reduce visibility by mucosal edema and obstruction. Increased stone density measured in HU also affects stone fragmentation and clearance rate. In our study, we found a mean HU of 992.62±263.75. Amin MA *et al.* evaluated the usefulness of measuring stone density in Hounsfield Units by Low-dose Non-Contrast Computed Tomography scan in predicting the outcome of extracorporeal shockwave lithotripsy for renal stone clearance.[12] They found 78.8% of the patients with stone density ≤750 HU exhibited complete clearance of stone as opposed to 37.5% of those with stone density>750 HU. The chance of having complete stone clearance is 6-fold (95% CI = 1.9-19.4) higher in patients with low-density stone (≤750 HU) than in patients with high-density stone (>750HU) (p=0.002).

Limitations of The Study

This study was conducted at a single center and involved multiple surgeons. Different sizes and types of ureteroscopes were used, and stone fragmentation was performed using both pneumatic and laser energy sources. Additionally, the sample size was small, and patients were not selected randomly, which may limit the generalizability of the findings.

CONCLUSION

The STONE score is a significant predictor of stone-free status after ureteroscopy, with lower scores (5–8) linked to 100% stone clearance and fewer complications. Stone-free patients had a significantly lower mean score (9.39±1.86) than those with residual stones (12.33±1.03, p<0.05). Logistic regression confirmed that higher STONE scores reduce the chance of stone clearance (OR 0.448, p=0.043), while operative time and hospital stay were not significantly affected. Thus, the STONE score effectively predicts ureteroscopy outcomes.

Recommendation

It is recommended that larger, multicenter studies with standardized surgical techniques and randomized patient selection be conducted to further validate the predictive value of the STONE score and optimize ureteroscopy outcomes.

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