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Original Research Article

Comparison of S.T.O.N.E score with Guy's stone score as a tool to predict stone clearance rates in patients undergoing percutaneous nephrolithotomy: a single center study

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ABSTRACT

Background: We aimed to compare the Guy's stone score and S.T.O.N.E nephrolithometry score and assess their predictive accuracy for percutaneous nephrolithotomy (PCNL) outcomes.
Methods: A total of 100 patients, who underwent PCNL between Jan 2018 and Dec 2018 were included in the study. All patients were evaluated with computerized tomography (CT) scan preoperatively and scores were calculated. Patient demographic characteristics, intraoperative and postoperative variables were evaluated. The relationship between the Guy's and S.T.O.N.E scores, and their prediction for postoperative stone-free status, complications were compared.
Results: The mean Guy's score was 2.04±1.01, and the mean S.T.O.N.E score was 8.0+1.7. The mean operative time was 101.9+41 minutes and the mean blood loss was 170+113ml. The complication rate in our study was found to be 32%, majority were grade 1-2. Both scoring systems showed positive correlation with stone burden, operating time and blood loss. The overall stone free rate was 72% and both the GSS and S.T.O.N.E score were significantly associated with success of the procedure.
Conclusions: Both Guy's and S.T.O.N.E scoring systems are equally effective in predicting stone-free status.

Keywords: S.T.O.N.E score, Guy's score, PCNL, Renal stone, Scoring system

INTRODUCTION

The incidence of urolithiasis is approximately 5% to 10% within the general population.[1] The diagnosis usually requires CT scan which provides high resolution imaging for accurate characterization of the stone size, distribution, pelvicalyceal anatomy, renal anomalies and other anatomical relationships. Percutaneous nephrolithotomy (PCNL) has become the treatment of choice for large and complex kidney stones and are associated with highest stone free rates.[2,3]

Nephrolithometry scoring systems (NLSS) aim to predict preoperatively the stone-free status (SFS) and complications through assessment of the complexity of stones before performing a PCNL. The Guy's Stone Score (Table 1), the S.T.O.N.E nephrolithometry score (Table 2) are most used scores, so the authors decided to compare these scoring systems at their tertiary care hospital. Clinical research office of the endourology

society (CROES) nomogram, and the seoul national university renal stone complexity (s-resc) score are the other scoring systems used today.[4,5] In this study, we have applied these two tools on pre-operative CT scan to predict SFR after PCNL. Post PCNL assessment of residual stones was done using low dose non-contrast CT (NCCT) scan. The aim of this study was to compare both the scoring systems for prediction of post PCNL residual stones and complication rates.

Table 1: Guy's stone score.

Score	Description
1	A solitary stone in the mid-/lower pole with simple anatomy or a solitary stone in the pelvis with simple anatomy.
2	A solitary stone in the upper pole with simple anatomy or multiple stones in a patient with simple anatomy or any solitary stone in a patient with abnormal anatomy.
3	Multiple stones in a patient with abnormal anatomy or stones in a calyceal diverticulum or partial staghorn calculus.
4	Staghorn calculus or any stone in a patient with spina bifida or spinal injury.

Table 2: S.T.O.N.E score.

Variables	Score			
	1	**2**	**3**	**4**
Stone size(mm2)	0-399	400-799	800-1599	>1600
Tract length(mm)	<100	>100	-	-
Obstruction	No or mild hydronephrosis	Moderate or severe hydronephrosis	-	-
Calyces	1-2	3	Staghorn	-
Essence	<950HU	>950HU	-	-

METHODS

This prospective study was conducted in the department of Urology, Army Hospital Research and Referral, New Delhi between January 2018 to March 2019. 100 adult patients who were scheduled for PCNL for renal calculi at the department of Urology, Army Hospital Research and Referral, New Delhi were enrolled in study after taking informed consent. With the assumption of stone clearance rate of 86%6 and using the 95% confidence level, precision of+7.5%, the minimum sample size calculated was 86. The patients undergoing bilateral concomitant PCNL, patients with bleeding diathesis/ uncorrected coagulopathy and pregnancy were excluded from the study. The study was approved by the institute's ethical committee.

All patients underwent routine serum, urine examinations and a NCCT scan preoperatively and Guy's and S.T.O.N.E. score was calculated in all. Preoperatively, all patients received prophylactic antibiotics during the induction of anaesthesia or therapeutic antibiotics, according to the urine culture obtained before surgery.

All PCNL procedures were done by standard technique. Tract dilation was performed with dilators, and an Amplatz sheath (22F/26F/28F, as per requirement) was placed. Nephroscopy was performed with a rigid Storz nephroscope (standard/miniperc depending on stone burden) and stone fragmentation was performed with lithoclast. The intraoperative stone-free status was verified with combined fluoroscopy and nephroscopy. A nephrostomy tube was placed at the end of the procedure. Antegrade double-J stent was placed in all patients. Operative time was considered from the beginning of the cystoscopy for ureteral catheter insertion to the end of the nephrostomy placement.

Complete blood counts, blood urea, serum creatinine and serum electrolytes were performed postoperatively in all cases. Surgical complications were graded according to the Clavien system. Blood transfusion was considered for patients with significant blood loss or patients with signs of hypovolemia, refractory to fluid replacement. The S.T.O.N.E. and Guy's scores were calculated for each patient and their correlation with stone-free status, operation time and blood loss were evaluated. All patients underwent NCCT scan at 3 months postoperatively to calculate the SFR. Success rate was defined as the absence of residual stones or the presence of asymptomatic clinically insignificant residual fragments 4 mm on NCCT scan at 3 months post operatively.

Statistical analysis

All analyses were conducted using SPSS (version 17.0, SPSS Inc., Chicago, USA). A P value<0.05 (two-sided) was considered statistically significant. Categorical variables were compared with the Chi-square test. Continuous variables were compared with the Mann-Whitney-U test or the two-sample unpaired t-test. Logistic regression was applied to determine the independent effects features like patient characteristics

(age, sex, body mass index (BMI)), stone features (stone burden, number, tract length, location, presence of obstruction, number of involved calices, and essence), and perioperative data (number of punctures, number of tracts, operative duration and estimated blood loss (EBL)). Receiver operating characteristic (ROC) curves were generated to assess the predictive role of study parameters and both scoring systems on stone free rate.

RESULTS

The mean age in our cohort was 42.9+14.1 years. Male: female ratio was 1.94 with 66 males and 34 females. Mean BMI was found to be 25.5+3.4 kg/m2. 60% patients underwent surgery for left sided stones. 22% of the patients had history of prior treatment for ipsilateral stone disease. Among them, 10 had PCNL, 4 patients had open pyelolithotomy and 8 had Extracorporeal shock wave lithotripsy (ESWL) (Table 3).

In our cohort, multiple calculi (>1) in the same kidney was found in 51% of the cases. 18 patients among the study population had staghorn calculus. The mean stone burden, tract length and stone essence were 933.8+412 mm2, 96.3+12.3 mm2 and 876+199.7 respectively.

Table 3: Demographics and perioperative characteristics.

Variables	Mean±SD
Age (years)	42.9±14.1 (18-75)
Gender (male/female) (N)	66/34
BMI (kg/m^2)	25.5±3.4 (16.2-38.2)
Laterality (right/left)	40/60 (40.0/60.0)
Previous treatment for ipsilateral renal stones(n)	22
Stone number (single/multiple) (N)	49/51
Staghorn calculus (n)	18
Stone burden(mm^2)	933.84+412
Tract length(mm)	96.3+12.3
Essence (HU)	876+199.7
S.T.O.N.E. score	8.0±1.7 (5-12)
Guy's Score	2.04±1.01 (1-4)
Renal Punctures	1.1±0.4
Operation time (minutes)	101.9±41.1
Nephrostomy tracts	1.09+0.28
Estimated blood loss(ml)	172.35+113

Table 4: Comparison of stone free and non-stone free status with respect to demographic and stone characteristics.

Variable	Stone free (n=72)	Non-stone free (n=28)	P value
Age (years) (mean ± SD)	42.2±13.7	44.7±15.4	0.425
Gender [N (%)]			
Male	44 (66.7)	22 (33.3)	0.098
Female	28 (82.4)	6 (17.6)	
BMI (kg/m2) (mean ± SD)	25.5±3.5	25.4±4.4	0.929
Stone Laterality [N (%)]			
Right	26 (65.0)	14 (35.0)	0.203
Left	46 (76.7)	14 (23.3)	
Stone location			
Pelvis	22 (91.7%)	2 (9.3)	-
Calyx (sup or mid or inf)	20 (83.3%)	4 (17.7%)	
Multiple calyces	30 (57.7%)	22 (42.3%)	
Stone burden (mm^2)	868.1±367.6	1096.1±491.2	0.013*
Tract length (mm)	95.1+10.7	99.4+15.5	0.118
Number of calyces involved			
One	50 (80.6%)	12 (19.4%)	
Two – three	14 (70.0%)	6 (30.0%)	-
Staghorn	8 (44.4%)	10 (56.6%)	
Essence (HU)	854.0±191.7	932.8±215.4	0.078
Obstruction			
No/mild	38 (80.9%)	9 (19.1%)	
Moderate/severe	34 (64.2%)	19 (35.8%)	-

*statistically significant.

In our study, the mean Guy's score was 2.04+1.01 and mean S.T.O.N.E score was 8.0+1.7. Intra-operative variables such as renal punctures, nephrostomy tracts, operative time and estimated blood loss were also noted. The average operation time was 101.9+41.1 minutes with maximum time taken in one patient was 210 minutes. Intraoperative mean estimated blood loss was 172.35+113 ml. Overall complication rate was 32%. Significant complications (i.e. grade 3-5) were seen in 6%. Majority of the patients had clavien 1-2 complications. 1 patient had bleeding which was managed with angioembolization.

Table 5: Comparison of mean value of Guy's and S.T.O.N.E. score between stone free and non-stone free patients.

	Stone-free	Non-stone free	p-value
Guy's Score (Mean+SD)	1.82±0.89	2.61±1.10	0.001*
S.T.O.N.E score (Mean+SD)	7.65±1.55	8.86±1.88	0.001*

*statistically significant.

All patients were evaluated for stone free status at 3 months post op. 72 patients were found to be stone free and 28 were not stone free. Both the stone free and non-stone free groups were analyzed with respect to various patient demographic variables. There was no significant difference found among variables of age, gender distribution, BMI and stone laterality. There was a statistically significant association of stone location with SFR (p=0.003). Stones at multiple renal locations had worst clearance rates (57%), calyceal or diverticular stones had intermediate clearance rates (83.3%) and pelvic stones had good clearance rates (90%). There was a statistically significant difference in stone burden (p=0.013) between the stone free status and non- free status. There was no statistically significant difference in the tract length, number of tracts, degree of hydronephrosis and essence value of stone between the stone free group and non-stone free group (p=0.06). Number of calyces involved were statistically associated with SFR. The patients with a greater number of calyces involved had more residual stones (p=0.010) (Table 4).

There was a significant difference in the Guy's stone and S.T.O.N.E. scores of stone free and non-stone free patients with residual stone patients having greater scores than the stone free patients. (2.6+1.1 vs 1.8+0.8; p=0.001) and (8.9+1.9 vs 7.6+1.5; p=0.001) respectively (Table 5).

The association of individual Guy's score and S.T.O.N.E score was found to have significant association with SFR after PCNL (p=0.003 and 0.048 respectively). There were significant associations between both Guy's score and S.T.O.N.E. score, and postoperative complications (p=0.03) and (p=0.004), respectively (Table 6).

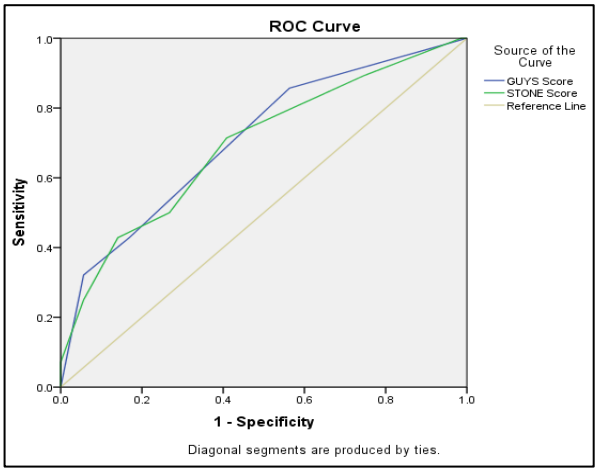

Table 6: Receiver operating characteristic curve for Guy's stone and S.T.O.N.E. score for prediction of success rate of percutaneous nephrolithotomy.

Table 6: Impact of Guy's and S.T.O.N.E. nephrolithometry scoring system on stone-free status, EBL and operative time.

Nephrolithometry Scoring system	B-coefficient	Odds ratio (OR)	95% C. I. for odds ratio		P value
			Lower	Upper	
Stone – free					
Guy's score	-0.769	0.464	0.294	0.731	0.001*
S.T.O.N.E. score	-0.409	0.664	0.509	0.867	0.003*
Estimated blood loss (EBL) (≥250 cc)					
Guy's Score	0.866	2.378	1.450	3.899	0.001*
S.T.O.N.E. Score	0.562	1.754	1.290	2.385	0.0001*
Operation time (min)					
Guy's score	21.575	NA	14.696	28.454	0.0001*
S.T.O.N.E. score	13.736	NA	9.836	17.636	0.0001*

*statistically significant.

Table 7: Area under curve for Guy's Stone and S.T.O.N.E. score for prediction of success rate of percutaneous nephrolithotomy.

Test result variable(s)	Area	Std. error	95% Confidence interval		P value
			Lower bound	Upper bound	
STONE score	0.710	0.058	0.596	0.824	0.001*
Guy's Score	0.694	0.060	0.576	0.813	0.003*

*statistically significant.

Both scores showed significant association with stone free rates. On the receiver operating characteristic curve, there was no significant difference in the area under the curve for the Guy's and S.T.O.N.E scoring systems (0. 710 [95% confidence interval (CI) 0.596-0.824] vs. 0.694 [95% CI 0.576-0.813]; P>0.05) and both the scoring systems have a good predictive rate for stone free status. (Table 7) (Figure 1).

DISCUSSION

Preoperative imaging methods play a critical role in arriving at an accurate diagnosis and optimum surgical management in patients with renal stones.[7] The ideal nephrolithometry score should be easy to use, reproducible, able to accurately predict stone free status and complications. There is no universally accepted ideal scoring system yet and to support further studies intending to develop the ideal scoring system, comparison of the recent scoring systems is very important. In our study we aimed to evaluate the Guy's and S.T.O.N.E scoring systems for predicting the PCNL stone free status and complications.

The mean age of our study group was 42.9 years with majority male patients (67%). Kumar et al and Bozkurt et al in their study had similar age distribution with 67% males and 33% females.[6,8] The various stone characteristics were also analyzed and compared with other series. Mean stone burden in our study was 933.84+412 mm^2 which was like Labadie et al who documented an average stone burden of 1089.5 mm^2.[9] The average stone burden in our series was higher than many other series as our hospital is tertiary care center where difficult and high stone burden cases are referred.[8,10] Mean tract length in our study was 96.3+12.3 mm, whereas it was found to be lower than study group by Tailly et al where mean tract length was 113mm.[11] This is self-evident as the mean tract length is measured as skin surface to stone distance and is highly dependent on the BMI of the patients.

Preoperative NCCT scan was used to calculate the scores. The mean Guy's and S.T.O.N.E score in our study was 2.04±1.01 and 8.0±1.7 respectively, which was consistent with majority of the authors.[10-12] Noureldin et al reported the mean Guy's score and S.T.O.N.E. score as 2.3+0.7 and 7.6+ 0.1 respectively.[10]

An overall complication rate of 32% was observed in our study, majority (26%) were clavien grade 1-2 and was managed conservatively. Significant complication (Clavein grade 3-5) were seen in 6% of the study population. 3 patients had hemothorax due to supracostal puncture and were managed with intercostal tube drainage; 1 patient had excess hematuria in the postoperative period which was managed with angioembolization of lower pole vessels. 2 patients had hematuria which required blood transfusion. Overall complication rate in literature in PCNL as per CROES PCNL global study is 20.5%.[12] The most frequent complications were fever and bleeding. Our complication results were comparable with those reported by Mandal et al (41.7%) and Smith et al (52%).[13,14] However, our complication rates were higher than many other studies.[15-17] The presence of large stone burden; resident training program and variable operative experience could have been amongst reasons for relative higher complication rates.

The success rate for SFR was 72% in our study group. Various authors reported little more success rate, such as Bozkurt et al (75.1%), Kumar et al (86%), Nourledin et al (72%) and Okhunov et al (80%).[6,8,10,12] The little lower SFR in our study could be attributed to our strict criteria using NCCT scan for documenting stone free status and varied experience of operating surgeons; however, multiple studies used conventional X-ray or Ultrasonography for determining SFR.

The patients were divided into stone free and non-stone free groups and the differences between the two groups were analyzed in relation to patient characteristics, stone variables and complications. Age, sex, BMI and stone laterality were found to be comparable in both the groups and were also consistent finding in other series.[10,13] Stones in multiple calyces had the worst clearance rates - 43%, while stone in pelvis had best stone clearance (90%). Labadie et al showed that stones in multiple calyces had poor clearance rates (71%) as compared to those in upper pole (47%).[9]

In our study, there was a significant difference in stone burden between the two groups (868.1±367.6 mm^2 vs 1096.1±491.2 mm^2; p=0.013) and an increasing stone burden has been found to be significantly associated with the residual stones. There was significant difference in the Guy's scores of stone free and non-stone free patients with residual stone patients having greater scores than the stone free patients. (2.6+1.1 vs 1.8+0.8; p=0.001). On further applying chi-square test, association of individual Guy's score was found to have significant association with SFR after PCNL. The Guy's stone scoring system success rate in our study was 89%, 70%, 73% and 36% for GSS 1,2,3 and 4 respectively. These findings were consistent with the original study by Thomas et al.[18]

There was a significant difference in the S.T.O.N.E. scores of stone free and non-stone free patients with residual stones having significant greater scores than the stone free patients (8.9+1.9 vs 7.6+1.5; p=0.001). Multiple studies found the reproducibility of S.T.O.N.E. score in detecting SFR status.[11,19]

Both the scoring systems corelated significantly with the complication rates. The area under curve of both scoring systems were compared and found to be equally effective in predicting the SFR. Labadie et al compared Guy's Stone Score, S.T.O.N.E. and CROES nephrolithometry nomograms in 246 patients and authors concluded that

these nephrolithometry nomograms were equally predictive for post-PCNL stone free rates.[9]

Both the scoring systems showed significant association between operation time and estimated blood loss on logistic regression analysis. Vicentini et al in a retrospective review of 155 supine PCNLs concluded that the Guy's stone score had significant effect on the stone-free status ($p<0.001$), operative time ($p<0.001$), and blood transfusion rates ($p=0.01$).[15]

Preoperative nomograms should be easy to interpret and able to counsel the patient regarding the complications and stone free rates. As per our study, both the scoring systems had comparable accuracies in predicting the SFR and either of the two scores can be used by endourologists in their daily practice. Both scoring systems can be rapidly assigned in the outpatient department and used to assist in counselling the patients.

The strength of our study was the prospective design, adequate sample size and strict use of NCCT scan for determining stone free status in the post-operative period.

Limitations

The study was single centered, and the patients were managed by different surgeons and trainees with variable expertise. We encountered problems in analyzing stone size in irregularly shaped stone, calculating tract length in case of multiple stones and obstruction differentiation into mild or moderate had interobserver variability. In our study, we encountered problems in calculating S.T.O.N.E. score, whereas Guy's score was easy to use, justifying use of Guy's score in routine outpatient basis. Our study is further limited by no comparison available for standard PCNL or mini PCNL. Further, large scale prospective studies can help in determining the need to develop new nomogram in order to solve problems encountered.

CONCLUSION

Preoperative scoring systems can prove a valuable tool for proper patient counseling about the stone-free rate and complications associated with PCNL. Both scoring systems are easy to use and reproducible. Both Guy's and S.T.O.N.E scoring systems are comparable in predicting post-PCNL stone-free status. There were significant associations between both scoring systems and postoperative complications and both were equally associated with EBL and operating time.

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