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Original Research Article

Comparison between different radiological scoring systems in predicting post-PCNL outcome

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ABSTRACT

Background: Various scoring systems, including Guy's stone score (GSS), S.T.O.N.E. score, and Clinical Research Office of the Endourological Society (CROES) nomogram, have been assessed for predicting post-percutaneous nephrolithotomy (PCNL) success in terms of stone-free status (SFS) and complications. Our study aims to determine the optimal predictor of SFS among these systems and assess their efficacy in predicting perioperative factors and complications, using modified Clavien grade.
Methods: This prospective hospital-based cohort study involved 107 patients aged ≥18 years who underwent standard PCNL (tract size >24 Fr) within a year. GSS, S.T.O.N.E. score, and CROES nomogram were calculated using preoperative computed tomography (CT) scans. Comparisons between 'stone-free' and 'residual-stone' groups were statistically analyzed.
Results: All parameters effectively predicted SFS. S.T.O.N.E. score exhibited excellent discriminatory power (AUC 0.844; 95% CI: 0.762-0.907), followed by GSS (AUC 0.756; 95% CI: 0.663-0.834) and CROES nomogram (AUC 0.749; 95% CI: 0.656-0.828). S.T.O.N.E. score, with an AUC of 0.844, proved the most accurate predictor at ≤7 cut-off. GUY's score correlated positively with operative time and hospital stay (correlation coefficient 0.403, 0.34). S.T.O.N.E. score also positively correlated with these factors (correlation coefficient 0.443, 0.37). CROES nomogram negatively correlated with operative time and hospital stay (correlation coefficient -0.374, -0.314).
Conclusions: All scoring systems effectively predict post-PCNL SFS, with S.T.O.N.E. score being the most predictive. GSS and S.T.O.N.E. score associate significantly with operative time and hospital stay. Both GSS and S.T.O.N.E. score show significant associations with perioperative complications assessed by modified Clavien grade.

Keywords: Percutaneous nephrolithotomy, Nephrolithometry scoring systems, Guy's stone score, S.T.O.N.E. score, CROES nomogram

INTRODUCTION

The prevalence of urolithiasis is around 15% worldwide. It is found to vary with age, sex, race, geographical location and is having a rising trend world over.[1,2] It is mainly attributed to the increased use of computerized tomography as an imaging modality.[3] Correspondingly, the use of percutaneous nephrolithotomy (PCNL) as a modality of treatment for renal stone disease has also been increasing.[4-6] PCNL has emerged as the gold standard treatment even for large and complex renal stones and is recommended by many guidelines such as the European Association of Urology and the American Urology Association. The PCNL success rate ranges from 56% to 96% according to various series. Stone size, location, number, density, calyceal anatomy, patient characteristics including obesity, previous renal surgical history, as well as the surgeon's skill, all play important roles in the outcome of PCNL. As a preoperative assessment technique, computed tomography (CT) has had a

significant influence by giving a high-resolution spatial image for precise estimation of stone burden and distribution, calyceal morphology, renal abnormalities, etc. that determine the success of PCNL.[7,8]

Several scoring systems like Guy's stone score (GSS), S.T.O.N.E. nephrolithometry, CROES nomogram were developed to predict the success of PCNL in terms of stone-free status (SFS).[9-11] It was Thomas et al who first described the GSS for prediction of SFS after PCNL.[9] This scoring system is reproducible, provides quick and simple office-based classification of renal stones into different grades using only intravenous urography (IVU) even, and correlates well with the SFS. However, it ignores the size and density of the stone. S.T.O.N.E. Nephrolithometry scoring system of Okhunov et al is based on non-contrast CT (NCCT) having five variables, with score of 5-6 (low complexity) have overall SFS of 94-100%, score of 7-8 (moderate complexity) have overall SFS of 83-98% and score 9-13 (high complexity) have overall SFS of 27-64%.[10]

Further, greater S.T.O.N.E. scores are found to be associated with a greater estimated blood loss (EBL), longer operative times (OT), and increased length of stay (LOS) in hospital. Based on a global database study of 5830 patients using six factors, Smith et al designed the Clinical Research Office of the Endourological Society (CROES) nephrolithometry nomogram for SFS prediction following PCNL, obtaining a remarkable 76% prediction accuracy.[11] Nevertheless, calculating nomograms is frequently laborious and time-consuming.

The scoring method aids in preoperative patient counselling regarding the likelihood that they would be stone-free following PCNL. It can be used to categorize disease severity and determine who should be referred to a higher-level specialized centre. Another benefit is the potential for uniform reporting across institutions, which would raise the standard of urologic research as a whole.

The primary objective of our study is to determine which scoring system—GSS, S.T.O.N.E. score, or CROES score - best predicts the SFS after conventional PCNL. The effectiveness of these scoring systems in predicting perioperative morbidities, which are measured in terms of EBL, OT, LOS, and peri-operative complications, was also tested.

Aims and objectives

Aims and objectives of the study were to find out which among the three scoring systems (GSS, S.T.O.N.E score and CROES score) is the best predictor of SFS, and to evaluate how effective these scoring systems are in predicting perioperative morbidities which shall be assessed in terms of estimated blood loss (EBL), operative time (OT), length of stay in hospital (LOS) and perioperative complications.

METHODS

All patients more than 18 years of age who undergo standard PCNL in the department of urology in Government Medical College, Kozhikode in the study time period was included for evaluation. Informed consent was obtained from all eligible patients. All demographic data and perioperative information was tabulated. CT/IVP was done in all patients preoperatively and GSS, S.T.O.N.E score and CROES score calculated. All procedures were performed under general anaesthesia under 3rd generation cephalosporins (cefoperazone+ sulbactam) antibiotic coverage in prone position. Fluoroscopy guided punctures were done. Amplaz sheaths used were of size 28 Fr or more. 24 Fr Nephroscope was used in all cases. Fragmentation was done with pneumatic lithoclast and laser. Fragments were flushed out of system or removed with forceps. At the end, fluoroscopy was done to check for residual stones and cross checked with nephroscope. As institutional protocol for standard PCNL, we routinely placed 16 Fr nephrostomy tube, give manual compression at puncture site for 8- 10 minutes, take purse-string suture around the tube and keep it clamped for at least 6-8 hours. Postoperatively, X-ray kidney-ureter-bladder (KUB) was done on day-two to check the stone clearance. We defined SFS in our study as absence of residual stones or stone fragments <4 mm. We classified all complications according to the modified Clavien grades. Operative time, EBL (drop of hemoglobin on hemogram after 6 hours after adjustment of blood transfusion if given), complications if any, LOS or perioperative events within 30 days were noted in tabulated form.

Study design

It was a hospital- based prospective cohort study.

Setting

All patients more than 18 years of age who undergo standard PCNL (tract size >24 Fr) for radio opaque stones, from the department of urology, Government Medical College, Kozhikode.

Period of study

The duration of the study was 12 months (December 2021 – November 2022).

Sample size

The sample size was calculated as shown below.

$$N = 4 \times specificity \times (100 - specificity) \div (precision)^2 \times (1 - propensity\ of\ stone\ clearance)$$

According to a study conducted by Labadie et al, values are substituted as follows i.e.[12]

$$N = (4 \times 92.5 \times 7.5) \div 122 \times (1 - 0.821)$$

Hence sample size is calculated as 107.

Inclusion criteria

Those patients who are more than 18 years of age and are willing to participate in the study, and patients who are presenting with indications for PCNL were included.

Exclusion criteria

Patients who are presenting with contra indications for PCNL, patients less than 18 years of age, who are not willing to participate in the study, opting out from the project during the study time, with radioluscent stones on preoperative imaging, and with preoperatively placed PCN tube or double J (DJ) stent were excluded.

Statistical analysis

The presentation of the categorical variables was done in the form of number and percentage (%). On the other hand, the quantitative data were presented as the means±SD and as median with 25th and 75th percentiles (interquartile range). The following statistical tests were applied for the results:

The association of the variables which were quantitative in nature were analysed using Independent t test (for two groups) and analysis of variance (ANOVA) test (for more than two groups).

Spearman rank correlation coefficient was used for correlation of GUY score, S.T.O.N.E score and CROES nomogram score with operative time (minutes), blood loss (ml) and duration of hospital stay (days).

Receiver operating characteristic curve was used to find out cut off point, sensitivity, specificity, positive predictive value and negative predictive value of GUY score, S.T.O.N.E. score and CROES nomogram score for predicting stone free status, intra-operative complications, complications (within 30 days). Delong et al test will be used for comparison of area under curve.

Univariate and multivariate logistic regression was used to find out significant factors affecting stone free status, intra-operative complications.

Univariate and multivariate linear regression was used to find out significant factors affecting blood loss, duration of hospital stay(days), modified Clavein grade and operative time.

The data entry was done in the Microsoft excel spreadsheet and the final analysis was done with the use of statistical package for social sciences (SPSS) software, IBM manufacturer, Chicago, USA, version 25.0.

For statistical significance, p value of less than 0.05 was considered statistically significant.

RESULTS

All the parameters had significant discriminatory power to predict stone free status. Discriminatory power of S.T.O.N.E. score (AUC 0.844; 95% CI: 0.762 to 0.907) was excellent and discriminatory power of GUY score (AUC 0.756; 95% CI: 0.663 to 0.834) and CROES nomogram score (AUC 0.749; 95% CI: 0.656 to 0.828) was acceptable. Among all the parameters, S.T.O.N.E. score was the best predictor of stone free status at cut off point of ≤7 with area under curve of 0.844 for correctly predicting stone free status.

Mean±SD of GUY score in patients with residual stone was 3.18±1.19 which was significantly higher as compared to cleared stone (2±1.09) (p value=0.0001).

Mean±SD of S.T.O.N.E. score in in patients with residual stone was 9.41 ± 1.37 which was significantly higher as compared to cleared stone (7.34±1.44) (p value <0.0001).

Mean±SD of CROES nomogram score in patients with cleared stone was 244.42±53.69 which was significantly higher as compared to patients with residual stone (194±55.26) (p value=0.0006) (Table 3).

Significant positive correlation was seen between GUY score with operative time (minutes), duration of hospital stay (days) with correlation coefficient of 0.403, 0.34 respectively. Non-significant mild positive correlation was seen between GUY score with blood loss (ml) with correlation coefficient of 0.093.

Significant positive correlation was seen between S.T.O.N.E. score with operative time (minutes), duration of hospital stay (days) with correlation coefficient of 0.443, 0.37 respectively. No correlation was seen between S.T.O.N.E. score with blood loss (ml) with correlation coefficient of -0.022.

Significant negative correlation was seen between CROES nomogram score with operative time (minutes), duration of hospital stay (days) with correlation coefficient of -0.374, -0.314 respectively. No correlation was seen between CROES nomogram score with blood loss (ml) with correlation coefficient of -0.056 (Table 5).

On performing univariate regression, GUY score, S.T.O.N.E. score, CROES nomogram score were significant factors affecting stone free status. With the increase in GUY score, S.T.O.N.E. score, chances of stone free status significantly decrease with odds ratio of 0.426 (0.26 to 0.698), 0.437 (0.292 to 0.654) respectively. With the increase in CROES nomogram score, chances of stone free status significantly increases with odds ratio of 1.017 (1.006 to 1.028) (Table 6).

On performing univariate regression, none of the score was significant predictor of blood loss.

GUY score, S.T.O.N.E. score and CROES nomogram score were significant factors affecting duration of hospital stay (days). With the increase in CROES nomogram score by 1 unit, duration of hospital stays significantly decreased by -0.008 days. With the increase in GUY score, S.T.O.N.E. score by 1 unit, duration of hospital stays significantly increased by 0.408, 0.316 days respectively (Table 7).

On performing univariate regression, GUY score, S.T.O.N.E. score, CROES nomogram score were significant factors affecting operative time. With the increase in CROES nomogram score by 1 unit, operative time significantly decreased by -0.131 minutes. With the increase in GUY score, S.T.O.N.E. score by 1 unit, operative time significantly increased by 7.07, 5.496 minutes respectively.

On performing univariate regression, GUY score, S.T.O.N.E. score, CROES nomogram score were significant factors affecting Modified Clavien Grade. With the increase in CROES nomogram score, modified Clavien grade significantly decreased. With the increase in GUY score, S.T.O.N.E. score, modified Clavien grade significantly increased.

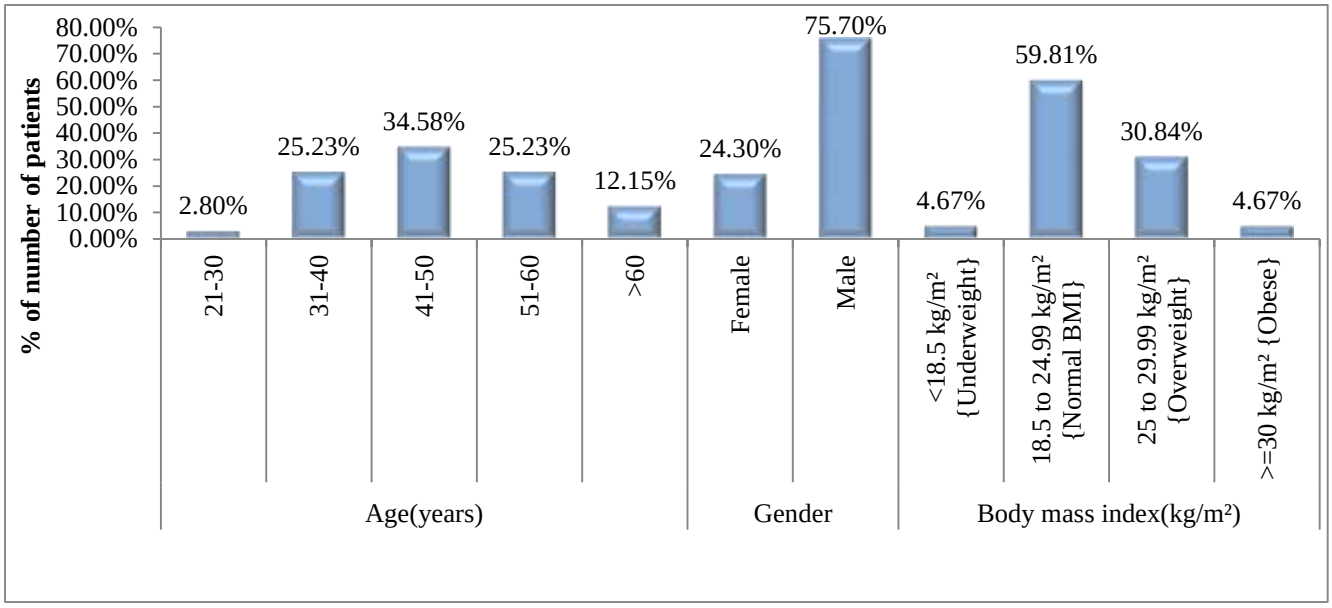

Figure 1: Distribution of demographic characteristics of study subjects.

Table 1: Descriptive statistics of various scores of study subjects.

Variable	Mean±SD	Median (25^{th}-75^{th} percentile)	Range
GUY score	2.19±1.18	2 (1-3)	1-4
S.T.O.N.E. score	7.67±1.61	7 (6-9)	5-12
CROES nomogram score	236.41±56.78	224 (192-295)	128-322

Table 2: Receiver operating characteristic curve of GUY score, S.T.O.N.E. score and CROES nomogram score for predicting stone free status.

Variables	GUY score	S.T.O.N.E. score	CROES nomogram score
Area under the ROC curve (AUC)	0.756	0.844	0.749
Standard error	0.0696	0.0413	0.0689
95% confidence interval	0.663 to 0.834	0.762 to 0.907	0.656 to 0.828
P value	0.0002	<0.0001	0.0003
Cut off	≤2	≤7	>198
Sensitivity (95% CI)	70 (59.4-79.2)	62.22 (51.4-72.2)	75.56 (65.4-84.0)
Specificity (95% CI)	76.47 (50.1-93.2)	94.12 (71.3-99.9)	70.59 (44.0-89.7)
PPV (95% CI)	94 (85.4-98.3)	98.2 (90.6-100.0)	93.2 (84.7-97.7)
NPV (95% CI)	32.5 (18.6-49.1)	32 (19.5-46.7)	35.3 (19.7-53.5)
Diagnostic accuracy (%)	71.03	67.29	74.77

Table 3: Association of different scores with stone free status in POD2.

POD2 status	Cleared (n=90)	Residual stone (n=17)	Total	P value
GUY score				
Mean±SD	2±1.09	3.18±1.19	2.19±1.18	0.0001*
Median (25th-75th percentile)	2 (1-3)	4 (3-4)	2 (1-3)	
Range	1-4	1-4	1-4	
S.T.O.N.E. score				
Mean±SD	7.34±1.44	9.41±1.37	7.67±1.61	<0.0001*
Median (25th-75th percentile)	7 (6-8)	9 (9-10)	7 (6-9)	
Range	5-11	7-12	5-12	
CROES nomogram score				
Mean±SD	244.42±53.69	194±55.26	236.41±56.78	0.0006*
Median (25th-75th percentile)	252 (200-299.5)	192 (160-214)	224 (192-295)	
Range	132-322	128-304	128-322	

Table 4: Association of different scores with modified Clavien grade.

Parameters	1 (n=76)	2 (n=19)	3a (n=11)	4 (n=1)	Total	P value
GUY score						
Mean±SD	2±1.1	2.26±1.24	3.27±1.19	3±0	2.19±1.18	0.007†
Median (25th-75th percentile)	2 (1-3)	2 (1-3.5)	4 (3-4)	3 (3-3)	2 (1-3)	
Range	1-4	1-4	1-4	3-3	1-4	
S.T.O.N.E. score						
Mean±SD	7.46±1.48	7.63±1.71	9.27±1.62	7±0	7.67±1.61	0.005†
Median (25th-75th percentile)	7 (6-8.25)	8 (6-8.5)	9 (8.5-10)	7 (7-7)	7 (6-9)	
Range	5-11	5-12	6-12	7-7	5-12	
CROES nomogram score						
Mean±SD	243.16±56.17	234±52.3	196.36±58.31	210±0	236.41±56.78	0.077†
Median (25th-75th percentile)	255 (196-300)	212 (194-282)	192 (150-228)	210 (210-210)	224 (192-295)	
Range	132-322	140-312	128-292	210-210	128-322	

† ANOVA

Table 5: Correlation of GUY score, S.T.O.N.E score and CROES nomogram score with operative time (minutes), blood loss (mL) and duration of hospital stay (days).

Variables	Operative time (minutes)	Blood loss (ml)	Duration of hospital stay(days)
GUY score			
Correlation coefficient	0.403	0.093	0.340
P value	<0.0001	0.341	0.0004
S.T.O.N.E. score			
Correlation coefficient	0.443	-0.022	0.370
P value	<0.0001	0.825	0.0001
CROES nomogram score			
Correlation coefficient	-0.374	-0.056	-0.314
P value	0.0001	0.565	0.001

Table 6: Univariate logistic regression to find out significant factors affecting stone free status.

Variable	Beta coefficient	Standard error	P value	Odds ratio	Odds ratio lower bound (95%)	Odds ratio upper bound (95%)
GUY score	-0.854	0.252	0.001	0.426	0.260	0.698
S.T.O.N.E. score	-0.828	0.206	<0.0001	0.437	0.292	0.654

Continued.

Variable	Beta coefficient	Standard error	P value	Odds ratio	Odds ratio lower bound (95%)	Odds ratio upper bound (95%)
CROES nomogram score	0.017	0.006	0.002	1.017	1.006	1.028

Table 7: Univariate linear regression between outcomes and various scores.

Variable	Beta coefficient	Standard error	P value	Lower bound (95%)	Upper bound (95%)
Blood loss					
GUY score	0.732	0.663	0.272	-0.582	2.047
S.T.O.N.E. score	-0.210	0.489	0.668	-1.179	0.759
CROES nomogram score	-0.005	0.014	0.731	-0.032	0.023
Duration of hospital stay					
GUY score	0.408	0.106	0.0002	0.198	0.618
S.T.O.N.E. score	0.316	0.077	0.0001	0.164	0.469
CROES nomogram score	-0.008	0.002	0.0005	-0.012	-0.004
Operating time					
GUY score	7.070	1.631	<0.001	3.836	10.304
S.T.O.N.E. score	5.496	1.183	<0.001	3.150	7.842
CROES nomogram score	-0.131	0.035	0.0002	-0.200	-0.063
Modified Clavien grade					
GUY score	0.187	0.056	0.001	0.076	0.298
S.T.O.N.E. score	0.118	0.042	0.006	0.035	0.200
CROES nomogram score	-0.003	0.001	0.015	-0.005	-0.001

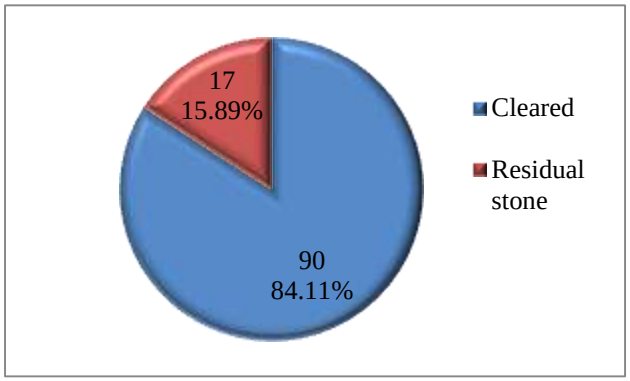

Figure 2: Distribution of stone free status on POD2 of study subjects.

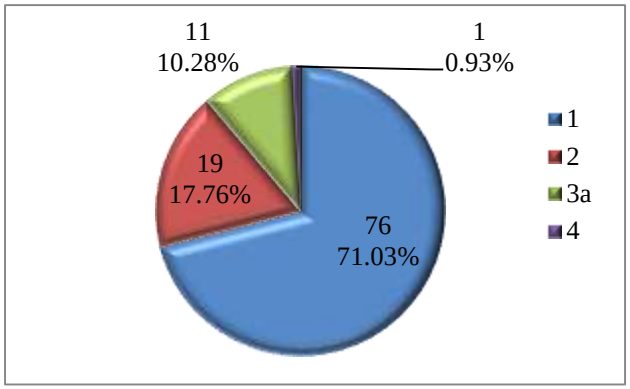

Figure 3: Distribution of modified Clavien grade of study subjects.

DISCUSSION

Our hospital is a moderate volume centre as far as PCNL procedure is concerned with more than 100 PCNL done in a year. We have considered average case volume per year as 100 cases for which the score granted is 90 in the CROES nomogram. The mean GUY's score was 2.19±1.18. The mean S.T.O.N.E score was 7.67±1.61 and the mean CROES nomogram score was 236.41±56.78.

The overall complication rate was 8.48 % in our study. Of these 3.74% were only mild post-operative fever and 2.80% needed blood transfusion in the perioperative period. One patient 0.93% had a serious complication, urinothorax and acute kidney injury (AKI) following PCNL. Delayed sepsis occurred in 5.61 % of the patients and one patient (0.93%) had pulmonary edema. This is much less compared to various studies which have quoted a major complication rate of around 7% and a minor complication rate of around 25% associated with PCNL.[12]

Complications following PCNL which were measured in terms of modified Clavien Dindo grade was significantly associated with GUY's stone score (p value 0.007) as well as S.T.O.N.E score (p value 0.005). But it was not significantly associated with CROES nomogram score (p value 0.077).

In our study, the stone free status among the subjects was found to be 84.11% where as 15.89% of the patients had residual stone after PCNL. In the literature, Smith et al had a stone free rate of 82%, Thomas et al had 62%, Okhunov

et al had a SFS of 80% and Labadie et al had SFS of 56%.[9-11,13]

When analysed in detail, we have found that higher GSS (p=0.002), higher S.T.O.N.E score (p<0.001) and lower CROES nomogram score (p=0.003) are associated with decreased SFS. The highest AUC was noted for S.T.O.N.E score and hence considered as the best predictor of SFS among the three scoring systems in this study. In this study all three scoring system were good at predicting stone free status after the PCNL. However, the discriminatory power of the S.T.O.N.E. score was excellent, with an AUC of 0.844 (95% CI: 0.762 to 0.907), while the discriminatory power of the GUY score and CROES nomogram score were acceptable, with AUCs of 0.756 (95% CI: 0.663 to 0.834) and 0.749 (95% CI: 0.656 to 0.828), respectively. Of all the parameters, the S.T.O.N.E. score was found to be the best predictor of stone-free status, with an AUC of 0.844 at a cutoff point of ≤7, indicating that it could correctly predict stone-free status with high accuracy.

It was Labadie et al who first conducted a similar study in a single cohort and found that all three scoring systems were significantly associated with SFS.[13] In a similar comparative study conducted by Akcay et al, it was noted that all three scoring systems can correctly predict success post PCNL of which CROES nomogram had the highest predictive value.[14] Tailly et al had conducted a large multicentric comparative study and had found that all three scoring systems are equally predictive of SFS post PCNL.[15] Singla et al had done a similar study in a small cohort and drew similar conclusions.[16] Noureldin et al had favoured GSS and S.T.O.N.E scores for their association with SFS.[17] Bozkurt et al had favoured GSS and CROES for their significant association with SFS.[18] Wu et al in their review article had stated the importance of each scoring system and their usefulness, mentioning that GSS was easy to apply even in a KUB radiograph, S.T.O.N.E needed CT KUB which was the preferred imaging modality in stone disease and CROES has high statistical power.[19] Vicentini et al had concluded that GSS was the easiest and quickest to calculate among these scoring systems.[8] While the AUC values for CROES and GSS were similar (0.641 and 0.653, respectively), S.T.O.N.E. had a lower AUC (0.563). However, two-by-two comparisons revealed no significant differences between the scoring systems. Similar to our study, they also found significant positive correlations between the GUY and S.T.O.N.E. scores with operative time and hospital stay duration. Similar to our results, they also did not find any correlation between the S.T.O.N.E. score and blood loss. They also reported a negative correlation was found between the CROES nomogram score and operative time and hospital stay duration.

A critical analysis of all these scoring systems was found in the review article by Vernez et al which mentioned that none of these scoring systems is superior to others and there is still room for yet another scoring system which accurately predicts the outcomes after PCNL.[20] Comparison of all four scoring systems was done in a recent study by Al Adl et al and they concluded that all the four scoring systems have comparable predictive accuracy and among these S.T.O.N.E was the easiest to calculate.[21]

Lai et al conducted a study to compare the predictive performance of five previously described scoring systems (S.T.O.N.E., Guy's, CROES, S-RESC, and SKS) for postoperative outcomes in adult patients regarding stone-free rate (SFR) and complications.[22] The study found that all five scoring systems significantly correlated with SFR, but S-RESC appeared to have the greatest predictive ability. After adjusting for potentially confounding factors, multivariate logistics analysis revealed that CROES, S.T.O.N.E., and S-ReSC score were the only significant independent predictors for SFR. ROC curves for each scoring system highlighted reasonable predictive capabilities, with AUCs of 0.709, 0.806, 0.869, 0.207, and 0.735, respectively. They reported that S-ReSC demonstrated the best discriminative performance. In our study we did not use S-ReSC, however, similar to our study, they also reported that both CROES and S.T.O.N.E. scoring system showed good capability to predict stone free status post-operatively.

Based on the findings of our study and review of literature we conclude that, all these three scoring systems are effective in predicting the SFS post PCNL surgery with the S.T.O.N.E score having the highest predictive accuracy. S.T.O.N.E is based on CT scan which is the best imaging modality for stone disease and is relatively easy to calculate, is reproducible and is not cumbersome when compared to nomogram scores. All the three scoring systems have been validated.[23-25]

Regarding our secondary objectives, we found that except for the CROES nomogram score, the other two scoring systems were significantly associated with perioperative complications which were assessed in terms of modified Clavien grade. On univariate regression analysis all the three scoring systems were predictive of complications in terms of modified Clavien grade but on multivariate regression analysis, none of the scoring systems were independent predictors of perioperative complications, when adjusted for confounding factors. Thomas et al in their original study had found no association of GSS with PCNL complications.[9] Noureldin et al had showed GSS and S.T.O.N.E score were not associated with intra operative complications.[17] Vicentini et al had showed in their study that GSS was associated with post PCNL complications.[8] Singla et al in their study had shown a weak association between all three scoring systems and modified Clavien Dindo grades.[16]

In our study, none of the scoring systems were found to have correlation with estimated blood loss (EBL). Krishnendu et al, in a similar study, had found that all three scoring systems were significantly correlating with EBL.[26] The OT time and LOS were significantly associated with all the three scoring systems. Labadie et al had showed

GSS and S.T.O.N.E score were associated with EBL and LOS but CROES was not significantly associated with EBL or LOS.[13] Tailly et al in their study had found S.T.O.N.E score was significantly associated with OT. Vicentini et al concluded that the GSS may also represent association with the OT, EBL, Complications and the need of auxiliary procedures.[8]

Our results are in concurrence with Kumar et al who conducted a study to compare the effectiveness of Guy's score and S.T.O.N.E. score in predicting the success and complication rate of PCNL.[27] The study found that both GSS and S.T.O.N.E. scores were equally effective in predicting the success rate of the procedure. Logistic regression analysis revealed that for every unit of increase in S.T.O.N.E. score, the operative time increased by 8.1 minutes ($p<0.001$) and for every unit of increase in GSS, it increased by 9.9 minutes ($p<0.001$). The length of stay also increased by 0.58 days ($p=0.001$) for every unit of rise in S.T.O.N.E. score and 0.84 days ($p<0.001$) for every unit of rise in GSS. The study further compared the area under the curve (AUC) for the Guy's and S.T.O.N.E. scoring systems on the receiver operating characteristic (ROC) curve, and found no significant difference between them (0.739 [95% confidence interval (CI) 0.665–0.813] versus 0.708 [95% CI 0.631–0.784]; $p>0.05$). Similar to our study, they also reported that both the scoring systems had a good predictive rate for stone-free status.

In their systematic review and meta-analysis, Jiang and colleagues aimed to assess the accuracy and feasibility of three different stone scoring systems in predicting SFR following PCNL.[28] The three stone scoring systems evaluated were Guy's stone score, CROES nomogram, and S.T.O.N.E. nephrolithometry scoring system. The meta-analysis included data from seven studies and found that all three SSSs were equally accurate and feasible in predicting SFR after PCNL, as measured by the AUC of the ROC curves. However, Guy's score was the only SSS that was able to predict complications after PCNL. In summary, the study suggests that all three SSSs are useful tools in predicting SFR after PCNL, but Guy's score may be more appropriate for predicting complications. In our study also, Guy's score was more appropriate for predicting complications.

The study conducted by Caglayan et al aimed to compare the effectiveness of two different scoring systems, GSS and CROES Nomogram, in predicting the outcomes of PCNL in pediatric patients with kidney stones.[29] The authors performed a multivariate analysis to identify the independent factors associated with the success of PCNL and the occurrence of complications. In contrary to our results, they found that the CROES score to be the independent factor associated with the success of PCNL, as indicated by the significant odds ratio (OR) of 0.984, 95% CI of 0.959-1.010, and p value of 0.017. On the other hand, having stones located in multiple calyces was the independent factor associated with complications, with an OR of 0.265, 95% CI of 0.087-0.808, and p value of 0.02. Overall, the study suggests that the CROES Nomogram may be more effective than the GSS in predicting the success of PCNL in paediatric patients with kidney stones. This in contradiction with our results and may be because of the difference in our study population.

Overall, the strength of our study was that the study was done prospectively in a relatively large cohort (n=107) which is fairly good enough to draw statistical conclusions. All scoring calculations were done on the basis of CT with no interobserver bias.

The possible limitations of the study were that, we had excluded pre stented patients and those patients who were on DJ stent to avoid difficulty in calculating S.T.O.N.E score in a de obstructed system. We did not do NCCT for all patients routinely to detect SFS post operatively as was done by Okhunov et al and Labadie et al. That was because we felt doing NCCT routinely in all patients would result in unnecessary radiation exposure to many patients and doing X ray KUB and USG in the post-operative period and during follow up would filter out those who actually need evaluation with a CT. Smith et al in their study used only X ray KUB to detect stone free status. Thomas et al had also used USG as a modality to detect stone fragments post operatively. We had also not considered the newer variations of PCNL such as the mini PCNL.

CONCLUSION

All three scoring systems are effective in predicting stone free status post PCNL and among these S.T.O.N.E score is the most predictive. GSS, S.T.O.N.E score as well as CROES nomogram have significant association with OT and length of stay in the hospital (LOS). GSS and S.T.O.N.E score have significant association with perioperative complications which are assessed in terms of modified Clavien grade.

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