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S.T.O.N.E. Score, Guy's Score, and CROES Nomogram in Predicting Stone Clearance following Percutaneous Nephrolithotomy

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ABSTRACT

Background

Percutaneous Nephrolithotomy (PCNL) is the standard treatment for large renal calculi. Several scoring systems have been developed to preoperatively predict its success. This study aims to compare the predictive accuracy of the Guy's Stone Score (GSS), S.T.O.N.E. nephrolithometry, and the Clinical Research Office of the Endourological Society (CROES) nomogram for stone-free status after PCNL.

Methods

A single-center, cross-sectional study was conducted from February 2021 to August 2022, including 75 patients who underwent PCNL. Preoperative variables were used to calculate the three scores. Stone-free status was defined as residual fragments <4mm on post-operative CT. The predictive ability of each score was assessed using Receiver Operating Characteristic (ROC) curve analysis, with comparison of the Area Under the Curve (AUC). Statistical analysis was performed using EZR version 1.36.

Results

The overall stone-free rate was 60%. The mean S.T.O.N.E. and CROES scores were 7.0±1.1 and 269.6±50.4, respectively. The AUC for predicting stone-free status was 0.768 for GSS, 0.673 for S.T.O.N.E., and 0.786 for the CROES nomogram. All three scores were statistically significant predictors (p-value<0.05). However, pairwise comparison of the ROC curves revealed no statistically significant difference in predictive accuracy between the three systems (p-value>0.05 for all comparisons).

Conclusions

The Guy's score, S.T.O.N.E. nephrolithometry, and CROES nomogram are all highly predictive of stone-free status following PCNL, providing a quick method for grading procedural complexity. No single scoring system demonstrated superior predictive value over the others, allowing for flexibility in their clinical application based on available imaging and surgeon preference.

Keywords: percutaneous nephrolithotomy; Guy's stone score; S.T.O.N.E. score; CROES Nomogram; stone free rate.

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INTRODUCTION

Urinary stone disease is a global health concern with a general population incidence of 5-10%, of which 15-20% of patients with renal stones require invasive intervention.[1] Percutaneous Nephrolithotomy (PCNL) is the first-line treatment for larger (>2cm) and more complex renal stones, offering a high stone clearance rate compared to other modalities.[2] Despite advancements in technique and technology, achieving complete stone clearance remains a challenge and is not always attainable.[3] An accurate preoperative estimate of treatment success is crucial for optimal decision-making, surgical planning, and informed patient counseling.[4] This need has led to the development of several scoring systems designed to predict outcomes. Among the most commonly used are the Guy's Stone Score (GSS), the S.T.O.N.E. nephrolithometry score (based on Stone size, Tract length, Obstruction, Number of calyces, and Essence/density), and the CROES nephrolithometric nomogram.[5-7] While previous studies have validated the individual predictive value of these systems, direct comparisons have yielded conflicting results on which is superior. This study aims to perform a comparative analysis of the GSS, S.T.O.N.E. score, and CROES nomogram in a single cohort to determine their relative efficacy in predicting stone-free rates after PCNL.

METHODS

This was a single-hospital-based cross-sectional study conducted at the Department of Urology, College of Medical Sciences, Bharatpur, from February 2021 to August 2022. The study was approved by the Institutional Review Board of COMS-TH. Written informed consent was obtained from all participants, and confidentiality was maintained. A total of 126 PCNL procedures were performed during this period. After applying exclusion criteria-28 cases of proximal ureteric calculi, eight patients under 18 years, five with prior nephrostomy tubes, and ten who declined post-operative CT-75 patients were included in the final analysis. The sample size was calculated using the formula for cross-sectional studies: $n=Z^2\alpha*p*(1-p)d^2$. Using a prevalence (p) of renal stone disease of 5% (0.05) in the Asian population, a Z-value of 1.96 for a 95% confidence level, and a margin of error (d) of 5% (0.05), the calculated sample size was 73.[1] Our study successfully enrolled 75 patients, meeting this requirement.

Preoperative non-contrast CT scans were used to calculate the S.T.O.N.E. score (components: Stone size, Tract length, Obstruction, Number of involved calyces, and Essence/stone density) and the CROES nomogram score (components: stone burden, location, count, prior treatment, and case volume). The Guy's Score was assigned based on stone characteristics and renal anatomy as per its original description. The primary outcome was stone-free status (SFS), rigorously defined as the absence of any residual fragments >4mm on a post-operative CT scan. Data were entered into MS Excel, cleaned, and analyzed using EZR software (version 1.36). Descriptive statistics were presented as mean ± standard deviation for continuous variables and frequency/percentage for categorical variables. The Chi-square and Fisher's exact tests were used for categorical comparisons. The predictive power of each scoring system was evaluated using Receiver Operating Characteristic (ROC) curve analysis, and the Area Under the Curve (AUC) values were compared pairwise using the method described by DeLong et al. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 75 patients were analyzed, with a mean age of 40.1±13.6 years. The cohort was predominantly male (64%). The overall stone-free rate was 60% (45/75). The distribution of patients according to the Guy's Stone Score and the components of the S.T.O.N.E. score are detailed in Table 1.

Stone location significantly impacted clearance. Pelvic stones had a 62.5% clearance rate, while lower pole (26.1% clearance, p-value=0.001) and upper pole stones (27.3% clearance, p-value=0.02) had significantly lower success rates (Figure 1).

Table 2 summarizes the impact of stone location on the success of Percutaneous Nephrolithotomy

Table 1. Baseline characteristics and scoring system distribution. (n=75)

Variable	Frequency (%)
Sex	
Male	48(64.0)
Female	27(36.0)
Guy's Score	
Grade I	40(53.3)
Grade II	20(26.7)
Grade III	13(17.3)
Grade IV	2(2.7)
Stone Size (S.T.O.N.E.)	
0-399 mm^2	68(90.7)
400-799 mm^2	6(8.0)
800-1599 mm^2	1(1.3)
Stone Density (S.T.O.N.E.)	
< 950 HU	21(28.0)
≥ 950 HU	54(72.0)
Residual Stone	
Absent (Stone Free)	45(60.0)
Present	30(40.0)

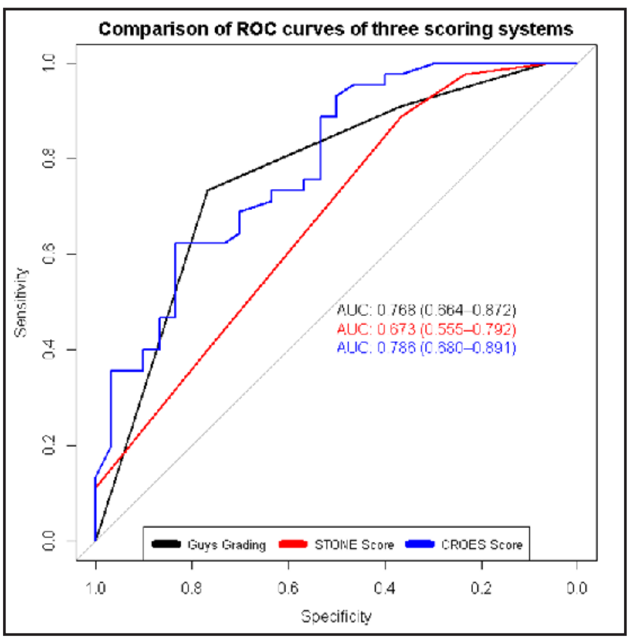

Figure 1. Receiver operating characteristic (ROC) curves for the three scoring systems

(PCNL). The stone-free rate was highest for stones located in the renal pelvis (62.5%) and middle pole (63.6%). In contrast, clearance rates were significantly lower for stones in the upper pole (27.3%), lower pole (26.1%), and for complex stones such as those

Table 2. Stone clearance rate by anatomical location.

Stone Location	Total patients (n)	Stone Free, n(%)	Residual Stone, n(%)	p-value
Pelvis	64	40(62.5)	24(37.5)	0.33
Upper pole	11	3(27.3)	8(72.7)	0.02
Middle pole	11	7(63.6)*	4(36.4)*	1
Lower pole	23	6(26.1)	17(73.9)	0.001
Multiple locations	5	1(20.0%)	4(80.0)	0.15
Staghorn	15	3(20.0)	12(80.0%)	0.001

in multiple locations (20.0%) and staghorn calculi (20.0%). Statistical analysis (p-value) confirms that the poor clearance rates for upper pole, lower pole, and staghorn stones are significant and not due to random chance (Table 2).

Crucially, the pairwise comparison of the AUCs revealed no statistically significant difference between any of the scoring systems (GSS vs. S.T.O.N.E., p-value=0.157; GSS vs. CROES, p-value =0.671; S.T.O.N.E. vs. CROES, p-value=0.099).

DISCUSSION

The primary objective of this study was to directly compare the predictive accuracy of three established nephrolithometry scoring systems-Guy's, S.T.O.N.E., and CROES-for stone-free status after PCNL. Our findings confirm that all three are valuable and statistically significant tools for this purpose, with AUC values indicating good predictive ability (0.673-0.786). Most importantly, we found no statistically significant difference in their performance, suggesting that no single system is superior to the others in our patient cohort. Our results are in strong agreement with several previous comparative studies. Labadie et al., in one of the first studies to compare all three systems, also found that all scores were significantly associated with SFR without a clear winner.[8] Similarly, Vicentini et al. reported no significant difference in the ability of GSS (AUC=0.653), S.T.O.N.E. (AUC=0.563), and CROES (AUC=0.641) to predict immediate PCNL success.[9] A more recent study by Biswas et al.[10] concluded that all three systems had similar predictive accuracy, with AUCs of 0.79 for GSS, 0.83

Table 3. Predictive performance of the three scoring systems.

Scoring System	AUC	95% Confidence Interval	p-value	Sensitivity (%)	Specificity (%)
Guy's Score	0.768	0.664 - 0.872	0.002	73.3	76.7
S.T.O.N.E. Score	0.673	0.555 - 0.792	0.004	88.9	36.7
CROES Nomogram	0.786	0.680 - 0.891	<0.0001	75.6	53.3

for S.T.O.N.E., and 0.81 for CROES, which closely mirrors our findings.[10]

When comparing individual scores, our AUC for the Guy's Score (0.768) is consistent with the original study by Thomas et al. and validations by others.[5, 11] The strength of GSS lies in its clinical simplicity and high specificity (76.7% in our study), making it excellent for identifying cases that will likely be successful. However, its reliance on broader anatomical categories may lack the granularity provided by CT-based systems.

Our S.T.O.N.E. score AUC of 0.673 is slightly lower than some reports, such as Okhunov et al. (AUC not directly stated, but score correlated well with SFR) and Noureldin et al. (AUC 0.71).[6, 12] Notably, our data showed it had the highest sensitivity (88.9%) but the lowest specificity (36.7%). This suggests that while a low S.T.O.N.E. score is very good at ruling out treatment failure (high sensitivity), a high score may over-predict complexity, leading to false positives.

The CROES nomogram performed excellently in our cohort, achieving the highest AUC (0.786). This aligns with its development from a large, multinational database, suggesting good generalizability. Smith et al. reported an AUC of 0.76, while Kumar et al. and Sfoungaristos et al. found AUCs of 0.67 and 0.71, respectively.[7, 13, 14] Its continuous scale allows for a more nuanced risk assessment compared to the categorical grades of GSS.

The clinical implication of our study is significant. It provides urologists with the flexibility to choose a scoring system based on available resources and clinical context. In settings where CT is not routinely available preoperatively, the Guy's Score remains a robust and reliable tool. When a pre-operative CT scan is obtained, both the S.T.O.N.E. score and the CROES nomogram offer excellent predictive value, with the CROES nomogram potentially having a slight edge in overall accuracy, though not statistically significant.

Limitations

Our study is not without limitations. Its single-center design and modest sample size, particularly in the higher complexity groups (e.g., only 2 patients with GSS Grade IV), may affect the generalizability of the findings. Furthermore, we did not evaluate the correlation between these scores and complication rates, which is another critical dimension of PCNL outcomes.

CONCLUSIONS

This study successfully achieves its objective of comparing the three major PCNL scoring systems. The Guy's Score, S.T.O.N.E. nephrolithometry, and CROES nomogram are all effective and comparable tools for predicting stone-free status. Their use enhances preoperative planning and patient counseling. The choice of system can be tailored to individual practice patterns without a significant loss of predictive power.

Conflict of interest: None

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