Original Article

Reliability and validity of "S.T.O.N.E" nephrolithometry scoring system to predict the stone-free rate after percutaneous nephrolithotomy

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Abstract

Objective: The objective was to assess the reliability and validity of "S.T.O.N.E" nephrolithometry scoring system to predict the stone-free rate (SFR) after percutaneous nephrolithotomy (PNL).

Methods: A total of 123 patients with unilateral radiopaque stones ≥2 cm were included in the study. According to S.T.O.N.E score, five parameters available from preoperative computed tomography (CT) without contrast were measured: stone size (S), tract length (T), obstruction (O), number of involved calices (N), and essence of stone (E). The Stone free rates evaluated within one month postoperatively by plain X-ray and/or CT scan without contrast.

Results: The mean S.T.O.N.E. score in this study was 7.4 in stone-free (SF) group and 9.3 in residual stone group ($P = 0.0001$). Patients with SF comprised 82.1% after the first PNL, whereas 17.9% had significant residual stones >4 mm. Postoperative complications were 8%. The most common complications were bleeding requiring transfusion. The size of stone ($P = 0.002$) and number of calices involved ($P = 0.001$) had a statistically significant difference between patients with residual stones, other components were not. There was a statistically significant difference between non-SF and SF according to the hospital stay ($P = 0.002$).

Conclusion: This score predicted the clearance after PNL. The size of calculi and number of calices involved statistically affected the stone clearance, whereas other S.T.O.N.E scoring parameters were not. There was a statistically significant difference between SF and residual stones groups according to the hospital stay ($P = 0.0001$).

Keywords: Clearance, nephrolithometry score, percutaneous nephrolithotomy, stone

INTRODUCTION

The incidence and prevalence of kidney stones is more increased and that made urologists use multiple modalities for the management of renal stone with large size, such as percutaneous nephrolithotomy (PNL) more often.[1]

The standard system for classification of stone in the renal system is still not uniform, however guidelines for managing urolithiasis are available.[2]

In Okhunov et al.'s study, there is a novel "S.T.O.N.E" score which contains five elements measured from preoperative

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computed tomography (CT) of the abdomen and pelvis without contrast to assess the stone complexity that can predict the clearance after PNL. The stone score is measured using five elements: calculus size, stone-to-skin distance, obstruction degree, number of calyces involved, and stone essence.[3]

Thus, this prospective study was used to assess the reliability and validity of "S. T. O. N. E" nephrolithometry scoring system to predict the clearance rate after PNL.

METHODS

Study design
This was a prospective study done by the Urology Department, at Al-Azhar University Hospitals, on a group of patients who underwent PNL. A local ethical committee approved the study, and all patients provided a written informed consent before inclusion. We included in our study all adult patients (>18 years) with unilateral radiopaque renal stones >2 cm, who underwent single or multiple tract PCNL and had pelvi-abdominal noncontrast computed tomography (NCCT) at our hospitals before surgery. Patients with bilateral renal calculi, nonradiopaque stones, stones <2 cm, active urinary tract infection, patients with coagulopathy and bone abnormality or congenital deformity of the upper urinary system (i.e., congenital obstruction of plevi ureteric junction (PUJ), ectopic, and pelvic kidney), and past history of ipsilateral renal surgery were excluded from the study. The studied patients were evaluated preoperatively with full medical history including sex, age, and complete physical examination including body mass index (BMI). Length of hospital stay were measured. Laboratory tests included complete blood count, random blood glucose (RBG), Kidney function tests, liver function tests and coagulation profile, urine analysis and urine culture and sensitivity. Radiological investigations included kidney, ureter, and bladder (KUB) to exclude radiolucent stones and pelvi-abdominal NCCT to measure the stone parameter that can predict clearance after PNL were measured by professional radiologist. The stone score was measured using five elements. These include calculus size, stone-to-skin distance, obstruction degree, number of calyces involved, and calculus essence.[3] All procedures were done by expert urologist who had more than 10-year experience in endourology. All procedures were done under fluoroscopy with the patient in the prone position. Pneumatic lithoclast was used. If no calculi appeared with nephroscopy or fluoroscopic inspection, the operation was finished. The patient was evaluated postoperatively with KUB and/or CT scan without contrast (within 1 month) and was considered stone free (SF) when there were no

stones or clinically insignificant residual fragments (CIRF) ≤4 mm.

Statistical analysis of the data with univariate analytical tests, between patients with SF and patients with non-SF, was done. Comparison of continuous variables was done by Student's t-test or mann whiteny U-test whereas Chi-square test and Fisher's exact test were used to compare the categorical variables. $P < 0.05$ had a significant difference. Data were analyzed using the Statistical Program for the Social Science (SPSS) (SPSS Inc., Chicago, IL, USA) version 20.0. Quantitative data were expressed as mean ± standard deviation. Qualitative data were expressed in terms of frequency and percentage. Receiver operating characteristic curve analysis was used to find the overall prediction of parameters and to find the best cutoff value with detection of sensitivity and specificity at this cutoff value.

The outcome of our study was to detect the reliability and validity of "S.T.O.N.E" nephrolithometry scoring system to predict the stone-free rate (SFR) after PNL and compare it with other variables and the sum of the score for stone clearance and to predict intra- and postoperative complications after 1 month of PNL. The classification of complications regarding to the modified Clavien grading system was done.

RESULTS

Between January 2016 and July 2017, a total of 154 patients underwent PNL, 123 of them met the inclusion criteria of our study and underwent elective PNL for renal stone. The mean age of the patients was 43.84 ± 11.58 years, and the mean BMI was 28.6 ± 5.007 kg/m². Males were 71 (57.7%) and females were 52 (42.3%). The right side was 52%, and the left side was 48%. The SF occurred in 101 cases (82.1%) and non-SF occurred in 22 cases (17.9%). Eight patients underwent second look PNL due to multiple residual stones (ranges: 10–15 mm), two patients underwent nephrolithotomy 1-week post-PNL due to multiple large in-accessible residual stones, ten patients for extra corporeal shock wave lithotripsy (ESWL) (stones burden ranges: 6–10 mm), and two patients (stones burden <6 mm) for the follow-up [Table 1].

Relation between stone clearance and the S.T.O.N.E. nephrolithometry score
The total score ($P = 0.01$) was a statistically significant difference between non-SF and SF patients. The stones' size ($P = 0.01$) and the number of calices

involved (*P* = 0.001) had a statistically significant difference between non-SF and SF as the SFR was high when the calculi size and number of involved calices were low and vice versa. Tract length (*P*-value =0.124), degree of obstruction (*P*-value = 0.57) and stone density (*P*-value = 0.69) had no statistically significant difference between non-stone free and stone free according to those three components. The mean hospital stay with SF group was 5.16 ± 1.57 day, and the mean hospital stay with the non-SF group was 7.89 ± 4.32 day with a statistically significant difference between non-SF and SF according to the hospital stay (*P* = 0.002), [Table 2].

The relation between stone clearance and degree of complexity

In Figure 1 we show the relation between stone clearance and degree of complexity when SFR was 100% in low complexity patients, high SFR with moderate complexity and low SFR with high complexity patients.

Table 1: The demographic and clinical data of the 123 patients

Variable, total, *n* (%)	Group, mean (SD) or *n* (%)		P
	Stone-free	Residual stone	
Outcome	101 (82.1)	22 (17.9)	-
Age (years)	42.53±11.93	49.86±7.46	0.065
Gender			
Male	59 (83)	12 (17)	0.379
Female	42 (80)	10 (19)	
BMI (kg/m^2)	28.41±4.70	29.50±6.26	0.007
Side			
Right	48 (75)	16 (25)	0.32
Left	53 (89.8)	6 (10.1)	

BMI: Body mass index, SD: Standard deviation

Table 2: The stone characteristics used to calculate the S.T.O.N.E. score

Variable, total, *n* (%)	Group, mean (SD) or *n* (%)		P
	Stone-free	Residual stone	
Stone score	7.49±1.42	9.31±2.03	0.01
Size (mm^2)			0.01
0-399, 53 (43.08)	49 (92.4)	4 (7.5)	
400-799, 32 (26)	26 (81.2)	6 (18.7)	
800-1599, 20 (16.2)	15 (75)	5 (25)	
>1600, 18 (14.6)	11 (61.1)	7 (38.8)	
Tract length (mm)			0.124
<100, 79 (66.6)	68 (86)	11 (13.9)	
>100, 44 (35.7)	33 (75)	11 (25)	
Obstruction			0.5
None, mild, 82 (66.6)	66 (80.4)	16 (19.5)	
Moderate, severe, 41 (33.3)	35 (85.3)	6 (14.6)	
Number of calyces involved			0.001
1-2, 86 (69.9)	80 (93)	6 (6.9)	
3, 18 (14.6)	10 (0.5)	8 (0.4)	
Staghorn, 19 (15.4)	11 (57.9)	8 (42.1)	
"Essence" (Hounsfield units)			0.69
<950, 43 (34.9)	39 (90.6)	4 (9.3)	
>950, 80 (65)	62 (77.5)	18 (22.5)	
Length of stay (days)	5.16±1.57	7.89±4.32	0.002

SD: Standard deviation

ROC curve was used to define the best cutoff value of total score which was >7, with sensitivity of 66.7% specificity of 59.4% PPV of 48%, NPV of 76% with diagnostic accuracy of 68.5% ROC [Table 3].

All three had comparable accuracies with the area under curve (AUC) of 0.698 (95% confidence interval [CI] 0.609 – 0.778), 0.758 (95% CI 0.672 - 0.831), and 0.750 (95% CI 0.663 - 0.823) for stone size, number of involved calyces and S.T.O.N.E. nephrolithometry scoring system, respectively [Figure 2].

Regarding peri/postoperative complications, nine cases had Clavien Grade 2 and one had Clavien Grade 3. The most common complications were bleeding need blood transfusion in six cases. The mean of total S.T.O.N.E score for complicated cases was 8.38± 2.07 and for non complicated cases was7.63±1.50. There is no significant difference for total score between complicated and non complicated cases(*p*= 0.069) [Table 4].

DISCUSSION

Multiple scores describe renal stones and predict clearance after PNL, but none of these scoring systems were accepted universally.[4–7]

Thomas *et al.*, 2011, reported Guy's stone score for assessment the grading of complexity of PNL to predict the clearance post-PNL. This score was formulated using the stone size and calyceal configuration (Grade I–IV) on multivariate analysis independently; Guy's stone score could predict the clearance post-PNL.[6]

Another scoring system for staghorn stones was done. They used the stone burden and distribution of stone inside the renal tract and predict the dilation number and stages of operations used in PNL preoperatively.[7]
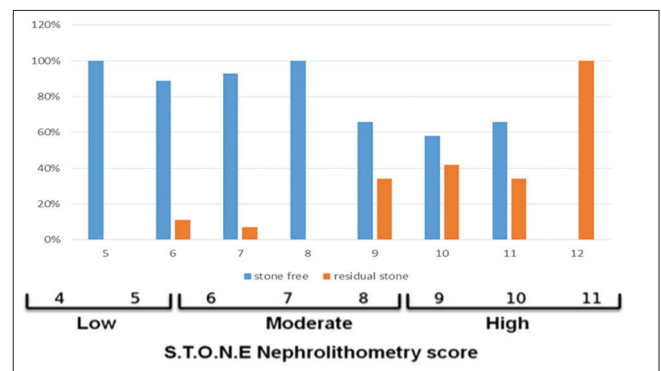

Figure 1: The relation between stone clearance and degree of complexity
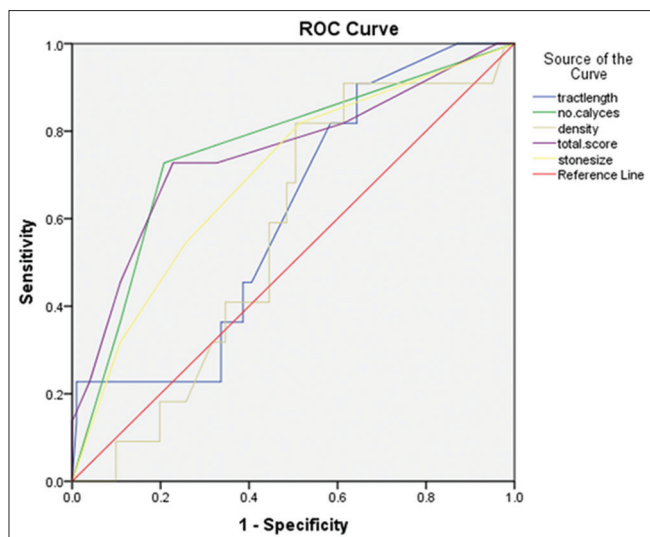
Figure 2: Receiver operating characteristic curves between nonstone free and stone free according to the total score of S.T.O.N.E nephrolithometry score and individual components

Table 3: Diagnostic performance of total score of nephrolithometry in the discrimination of nonstone free and stone free

Cutoff	Sensitivity	Specificity	PPV	NPV	Accuracy
>7	66.7%	59.4%	48%	76%	68.5%

ROC curve was used to define the best cutoff value of total score which was >7, with sensitivity of 66.7% specificity of 59.4% PPV of 48%, NPV of 76% with diagnostic accuracy of 68.5%. ROC: Receiver operating characteristics, PPV: Positive predictive value, NPV: Negative predictive value

Table 4: Complications of percutaneous nephrolithotomy classified according to the modified Clavien grading system

Grade	Complication	*n*
1	Transient elevation of creatinine	0
2	Blood transfusion	6
	Urine leakage <24 h	3
	Fever (UTI) requiring change of antibiotic	0
3a	Bleeding requiring transfusion+	0
	Angio-embolization due to AV fistula or pseudoaneurysm	0
	Urinary retention + colic due to blood clots	0
3b	Cystoscopic evacuation of clots	0
	Prolonged leakage requiring JJ stenting	1

UTI: Urinary tract infection, AV: Arteriovenous fistulae

Other authors[8] report a nephrolithometry nomogram Clinical Research Office of the Endourological Society (CROES) that depends on patient history and surgeon experience.

S.T.O.N.E. nephrolithometry score used five parameters that are quick, simple, reproducible, and easy to calculate from CT without contrast images to assess the stone parameter.[9]

Validation of a universal scoring system that assesses PNL complexity, postoperative complication, and predicts PNL outcomes will not only help urologists in preoperative patient counseling but also help in comparing PNL outcomes among different surgeons and centers. The current study assessed the reliability and validity of the S.T.O.N.E. nephrolithometry scoring system and helped to determine clearance post-PNL. In our study, there was no correlation between the S.T.O.N.E. score and postoperative complications. The stone size and number of calices involved significantly affected the SF status. Furthermore, hospital stay significantly affected the SF status; these are consistent with the results of the Okhunov *et al*.'s study.[3]

In our study, BMI, the hydronephrosis, and stone-to-skin distance were not significantly affect SFR. In another study, BMI and tract length affect the SFR.[9]

The mean S.T.O.N.E. score in this study was 7.4 in the SF group and 9.3 in the non-SF group, which is comparable to the mean S.T.O.N.E. score in other studies.[3,10] The SFR in the present study was 82.1%, with 8% postoperative complications. This is comparable to the 80% SFR and the 21% postoperative complication rate of the Okhunov

et al.'s study.[3] Noureldin *et al*. reported SFR 71.6%, with 15.5% postoperative complications.[10]

In Okhunov *et al*.'s study, stone complexity classified into a "low complexity" score of 3–5 with clearance rate of 94%–100%, a "moderate complexity" score of 6–8 with clearance rate of 83%–92%, and a "high complexity" score of 9–12 with clearance rate ranging of 27%–64%, but in our study, a "low complexity" score of 5 showing clearance rate of 100%, a "moderate complexity" score of 6–8 showing clearance rate of 89%–93%, and a "high complexity" score of 9–12 revealed clearance rate of 58%–66%, which is highly comparable.[3]

The limitation of our study was the small patient's numbers. Most of our patients (80 of 123) were divided into degree of "moderate complexity score of 6–8," according to the study of Okhunov *et al*.,[3] whereas only 4 and 39 were divided into degree of "low complexity" score of 3–5 and "high complexity" score of 9–12, respectively. Another limitation was a single-center experience which was done within a short time period. There is no significant difference for total score between complicated and non complicated cases ($P = 0.069$) may be due to small sample size . In future, multicenter with large-scale studies should be done to confirm our results.

CONCLUSION

The S.T.O.N.E. score predicts the clearance rate post PNL. The calculi size and number of involved calices

statistically affected stone clearance, whereas other STONE scoring parameters were not. There is no significant difference for total score between complicated and non complicated cases may be due to small sample size. In future, multicenter with large-scale studies should be done to confirm our results.

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Conflicts of interest
There are no conflicts of interest.

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