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ORIGINAL ARTICLE

# Evaluation of Nephrolithometric Scoring Systems to Predict Outcomes and Complications of Percutaneous Nephrolithotomy for Staghorn Stone

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## Abstract

**Background/Aim:** Urinary system stone disease develops with a frequency of 1-20 % in the general population. There are various surgical methods and percutaneous nephrolithotomy (PCNL) is a commonly used treatment method, especially in large, staghorn kidney stones. Aim of this study was compare stone nomograms in forecasting operative and complicating parameters subsequent to PCNL in staghorn stones.

**Methods:** The study analysed 66 patients with staghorn stones who underwent PCNL between 2017 and 2022, retrospectively. The researcher evaluated the Guy, S.T.O.N.E. and CROSS nephrolithotomy scores in patients using non-contrast computed tomography. The Clavien Dindo Classification was used to evaluate the surgical complication.

**Results:** The mean stone burden, GUY, S.T.O.N.E. and CROES scores were 1114.9 ± 520.18 $mm^2$; 3.64 ± 0.48; 10.11 ± 1.2 and 142.9 ± 31.99, respectively. Total stone-free status (SFS) was achieved in 37.9 % of the patients, while the median stone clearance rate was 93.74 (50-100). While no statistical significance was observed between GUY score and SFS, it was observed in S.T.O.N.E. and CROES scores (p = 0.020 and 0.004, respectively). ROC analysis showed that CROES and S.T.O.N.E. scoring systems and the stone burden parameter showed similar accuracy in the estimation of SFS. The results showed that only the S.T.O.N.E. score showed a significant relationship with the presence of complications (p = 0.034).

**Conclusion:** If the percutaneous nephrolithotomy for staghorn stones in question is, current scoring systems alone couldn't be predictive for postoperative outcomes and degree of complications. Further large scale multicentre prospective studies are needful.

**Key words:** Kidney stone; Percutaneous nephrolithotomy; Guy's Score; CROES nomogram; S.T.O.N.E. score.

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## Introduction

Urinary system stone disease develops with a frequency of 1-20 % in the general population depending on geographical, climatic, ethnic, nutritional and genetic factors,[1] 15-20 % of these patients require invasive intervention.[2] There are various surgical methods, especially endourological for stone treatment. Percutaneous nephrolithotomy (PCNL) is a commonly used treatment method, especially in large, staghorn kidney stones.[3, 4] However, it has been reported that the



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advantage of reduced operation time, low complication rate and short hospitalisation achieved by endourological stone surgery on non-staghorn stones cannot be achieved in the staghorn stone group with a higher residual stone rate.[5] Influencing parameters on postoperative outcomes, patient's anatomical and stone related factors, as well as surgical experience.[6] Different scoring systems were designed to evaluate stone free score (SFR's) preoperatively by using various clinical and radiological parameters. Guy's stone score (GSS), S.T.O.N.E. nephrolithometry score and Clinical Research Office of the Endourological Society (CROES) nephrolithometry nomogram are the best-known stone scores.[7]

It is important to use a reliable scoring system to predict PCNL outcomes. This study aimed to compare value of renal scoring nomograms in predicting PCNL with staghorn stones.

## Methods

Retrospective analysis of 400 patients with staghorn stones who underwent PCNL surgery between 2017 and 2022 was performed. Patients with bleeding diathesis, multiple comorbidities, non-standard PCNL and those with missing data were not included in the study. The remaining 66 patients were divided into two groups according to their stone-free status (SFS), 25 patients without stones in Group 1 and 41 patients in Group 2 with stone remnants after PCNL. The groups were compared to their demographic features, stone characteristics and operative parameters (nephrostomy length of stay, location and success, operation time and complications). Clavien grading system was used to evaluate postoperative complications. Biochemistry and complete blood count (CBC), kidney function analysis and haematological changes were recorded at most 1 week before the surgical procedure and on the 1st postoperative day.

Classifying of postoperative complications were performed by the valid Clavien score for PCNL.[11] Low dose non contrast computerised tomography (NCCT) and/or urography (only in complex cases), stone size (in $mm^2$ by multiplying the two longest dimensions), stone burden (by formula length x width x π x 0.25),[12] stone density (Hounsfield Unit), skin-to-stone distance (mm) as well as estimation of the most appropriate percutaneous access site with renal calyx anatomy were provided. S.T.O.N.E., GSS and CROES nomograms were calculated by the endourologists who mostly perform stone surgery in daily practice. Scoring started from Grade 3 in GSS and 7 in S.T.O.N.E. score due to the presence of staghorn stones. When calculating the CROES score, the average case volume for authors' clinic were 200 per year. While the literature was taken as a basis for the categorisation of the scores, only STONE 9-13 were evaluated by dividing into two classes.[13]

PCNL procedure started with 5 French (F) open-ended hydrophilic ureteral catheters (*Plasti-med*) retrograde placement in the involved kidney under general anaesthesia with 3rd generation cephalosporin prophylaxis and continued in prone position. With the initial puncture needle (18 G/20 mm/2 piece, *Plasti-med*), retrograde contrast was given under fluoroscopy and posterior calyx access was provided. Renal access was performed by entering a nephrostomy balloon dilator (*nephroflex*) up to 12 F after *amplatz* dilator and a 24 F nephroscope (*Alken-Hohenfellner*, Karl Storz, Germany) through a 30 F *amplatz* sheath. Stones were broken into piece by using pneumatic and ultrasonic lithotripters. After endoscopic and fluoroscopic stone free were achieved, a 14 F *malecot* nephrostomy set was placed in the kidney.

On the postoperative 1st day, both stone-free and pleural injury control were performed with direct urinary system radiography (X-ray kidney, ureter and bladder - KUB) and chest radiography. The patients were discharged after removal of the nephrostomy catheter, according to the dryness of the tract. Patient controls were provided with postoperative 1st month with urine analyses, X-ray KUB and ultrasonography and 3rd month with low dose NCCT. Absence of residual stones, including clinically insignificant fragments up to 4 mm, was a necessary condition for the success of the procedure.

### Ethical approval

The ethics committee approval of this study was obtained from local institution Ethic Committee on 02/2023 (No 2023/02/09/009). Informed consent from the patients was obtained.

### Statistical analyses

Statistical analysis study data was documented with Microsoft Excel 2019 and IBM SPSS and Statistics Standard GradPack was used for statistical analysis. After the normality test of the variables, the comparison of categorical and continuous variables was done with Chi-square or Fisher's exact test. The strength and direction of the relationship between two continuous variables was analysed using the Spearman rank correlation coefficient. Receiver operating characteristic (ROC) curves were generated to estimate the predictive value of stone scoring systems and preoperative stone burden for postoperative SFS. Regression analyses were performed to identify the likely relationship between stone scoring systems and preoperative stone burden among predicted blood loss (EBL), LOS, SFS and complications. $P < 0.05$ value was considered statistically significant.

## Results

Forty-six of the 66 patients eligible for the study were male and 36 patients were operated for left kidney stones. Seventy percent of 10 patients with partial staghorn stones were in the stone free group and showed statistical significance with the gender variable (p = 0.034, p = 0.015, respectively). Mean age and BMI were 50.30 ± 14.1 years and 25.95 ± 3 kg/m$^2$, respectively. The mean stone burden, GSS, S.T.O.N.E. and CROES scores were 1114.9 ± 520.18 mm$^2$; 3.64 ± 0.48; 10.11 ± 1.2 and 142.9 ± 31.99, respectively (Table 1).

Total SFS had 37.9 % of the patients, while the median stone clearance rate (SCR) was 93.74 (50-100). S.T.O.N.E. score and CROES nomogram showed statistical significance for SFS (p = 0.020 and 0.004, respectively), while GSS could not be associated with SFS (p = 0.09). Complications were not observed in 54.5 % of the cases. Clavien 1 group were 6.1 % and 13.6 %; Clavien 2 group rates were 4.5 % and 6.1 % and Clavien 3a group rates were 4.5 % and 7.6 % in the stone free and non-stone free groups, respectively. Clavien 3b

*Table 1: Patients' demographics and stone characteristics according to stone free status (SFS)*

| Parameters | SFS: Yes | SFS: No | p-value |
|---|---|---|---|
| Age (years) | 53.4 (13.4) | 48.41 (14.3) | 0.214 |
| BMI (kg/m$^2$) | 25.9 (2.8) | 26 (3.2) | 0.963 |
| Gender | | | |
| Male | 13 (28.3) | 33 (71.7) | 0.015* |
| Female | 12 (60.0) | 8 (40.0) | |
| The Guy's stone score | 3.52 (0.5) | 3.71 (0.5) | 0.128 |
| The STONE nephrolithometry score | 9.68 (1.2) | 10.37 (1.1) | 0.009 |
| CROES nomogram score | 156.20 (43.5) | 134.7 (18.5) | 0.011 |
| Stone burden (mm$^2$) | 909.18 (397.1) | 1240.30 (550.0) | 0.014 |
| Hounsfield unit | 908.40 (351.6) | 973.90 (278.0) | 0.526 |
| Skin to stone distance (mm) | 80 (16.1) | 80.60 (16.9) | 0.905 |
| Staghorn | | | |
| Partial | 7 (70.0) | 3 (30.0) | 0.034¥ |
| Complete | 18 (32.1) | 38 (67.9) | |
| Left side | 15 (60.0) | 21 (51.2) | 0.487* |
| Hydronephrosis [n (%)] | 9 (36.0) | 16 (39.0) | 0.806* |
| Renal anomaly [n (%)] | 1 (1.5) | 7 (10.6) | 0.143¥ |
| Hypertension [n (%)] | 8 (32.0) | 6 (14.6) | 0.094* |
| Diabetes [n (%)] | 4 (16.0) | 8 (19.5) | 1.00¥ |
| CAD [n (%)] | 5 (55.6) | 4 (44.4) | 0.282¥ |
| CKD [n (%)] | 3 (12.0) | 2 (4.9) | 0.359¥ |
| COPD [n (%)] | 2 (8.0) | 3 (7.3.0) | 1.00¥ |
| CVO [n (%)] | 1 (4.0) | 1 (2.4.0) | 1.00¥ |

**Pearson Chi-square; ¥: Fisher's exact test; Values are presented as N (%) or mean (SD); CAD: coronary artery disease; CKD: chronic kidney disease; COPD: chronic obstructive pulmonary disease; BMI: body mass index;*

complications were observed in 1 patient for residual stone group, Clavien 5 complications were observed in 1 patients for stone free group. The only scoring that showed a significant relationship with the presence of complications was the S.T.O.N.E. score (p = 0.034). The relationship between the three categorised scoring systems, SFS and complications is detailed in Table 2.

A robust correlation was noticed between the nomograms. The study found a positive correlation between the Guy's scoring system and operating table time (OTT) only (r = 0.328, p = 0.007). On the other hand, the S.T.O.N.E. score systems was positively correlated with OTT (r = 0.355, p = 0.002), while being negatively correlated with SCR (r = -0.378, p < 0.001). The only parameter that showed a strong correlation with all of the OTT, EBL and SCR parameters was the CROES score (Figure 1).

AUC and ROC curves showed that the STONE and CROES scoring systems and the stone burden parameter showed similar accuracy in the estimation of SFS (Figure 2) (p = 0.013; 0.012 and 0.014, respectively).

*Table 2: The relationship between nephrolithometric scoring systems, stone-free status and complications*

| Scoring system | SFS: Yes | SFS: No | p-value | Complications | p-value |
|---|---|---|---|---|---|
| **The Guy's stone score** | | | | | |
| Grade 3 | 12 (18.2) | 12 (18.2) | 0.187¥ | 13 (19.7) | 0.119* |
| Grade 4 | 13 (19.7) | 29 (43.9) | | 17 (25.7) | |
| **The STONE nephrolithometry score** | | | | | |
| 7-8 | 3 (4.5) | 2 (3.0) | 0.020¥ | 3 (4.6) | 0.013* |
| 9-10 | 18 (27.3) | 19 (28.8) | | 21 (31.8) | |
| 11-13 | 4 (6.1) | 20 (30.3) | | 6 (9.0) | |
| **CROES nomogram score** | | | | | |
| < 130 | 6 (9.1) | 23 (34.8) | 0.004¥ | 14 (21.2) | 0.339* |
| 130-169 | 12 (18.2) | 17 (25.8) | | 13 (19.7) | |
| 170-219 | 4 (6.1) | 1 (1.5) | | 1 (1.5) | |
| > 219 | 3 (4.5) | 0 (0.0) | | 2 (3.0) | |

*¥: Fisher-Freeman-Halton Exact Test; *One-way ANOVA test; SFS: Stone free status;*

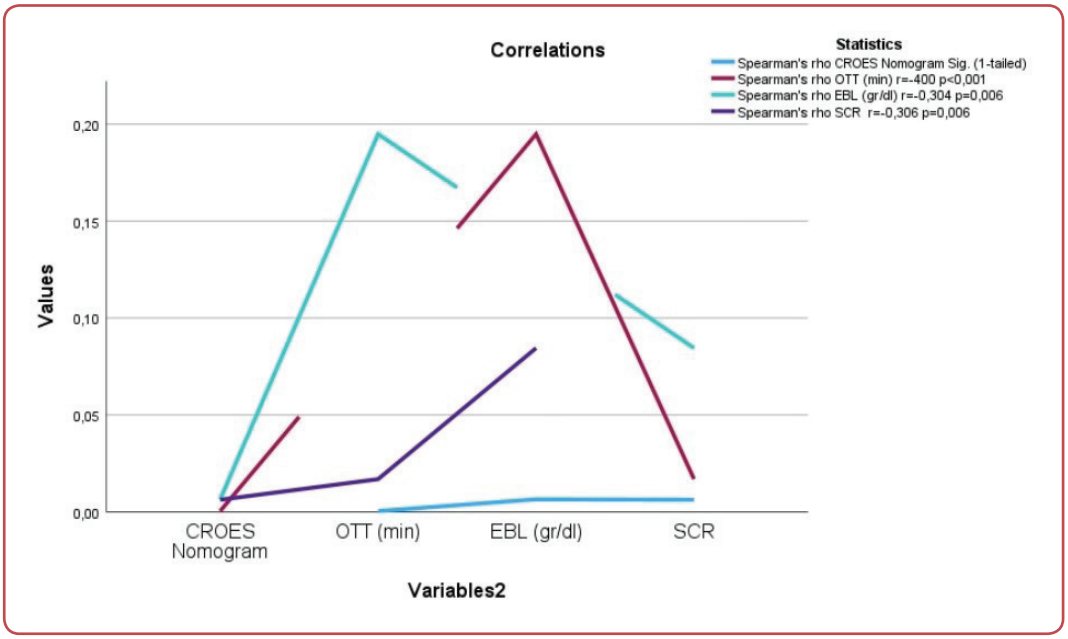


*Figure 1: Correlation line graphs between the CROES score and operation time table (OTT), estimated blood loss (EBL) and stone clearance rate (SCR)*

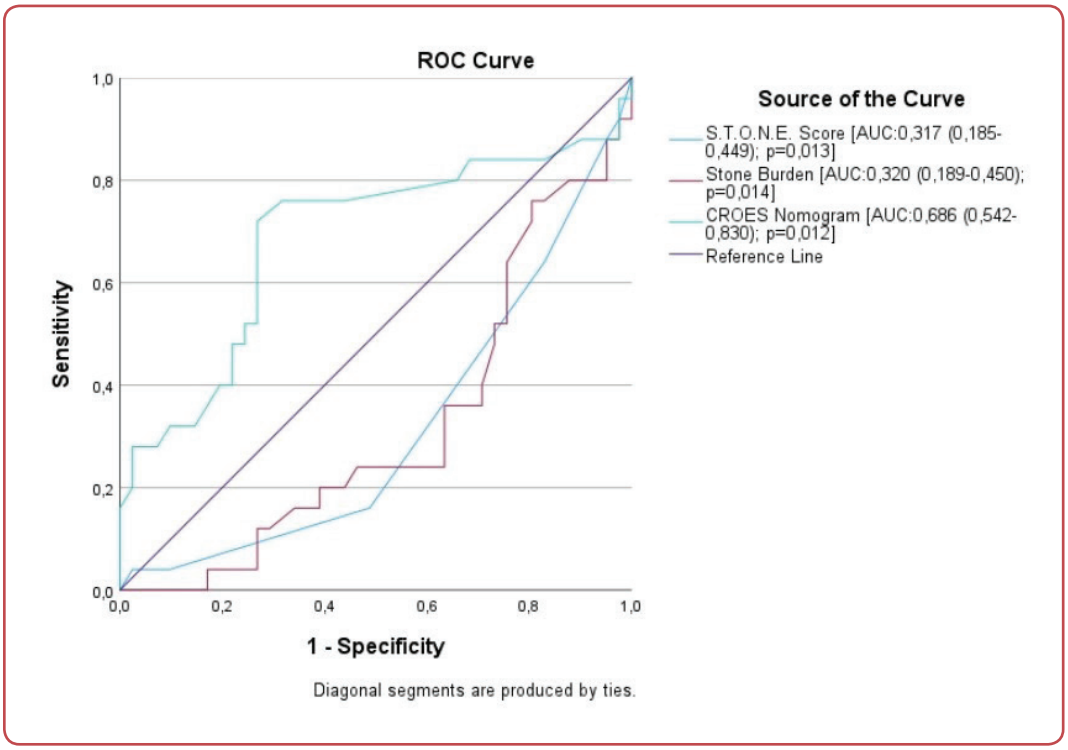


*Figure 2: Receiver operating curves (ROCs) and values for S.T.O.N.E. score, stone burden and CROES nomogram in predicting stone-free status (SFS)*

*Table 3: Linear and logistic regression analyses of stone burden and nephrolithometry scoring systems on operative parameters*

| Variables | B-coeff[a] / ORs[b] | 95 % CI | | p-value |
|---|---|---|---|---|
| | | Lower | Upper | |
| **SCR** | | | | |
| The STONE nephrolithometry score | -0.538[a] | -14.460 | -1.350 | 0.019 |
| CROES nomogram score | 0.304[a] | 1.110 | 9.110 | 0.013 |
| **OTT (min)** | | | | |
| CROES nomogram score | -0.334[a] | -2.360 | -0.021 | 0.021 |
| The Guy's stone score | 0.282 | 3.390 | 41.900 | 0.022 |
| **EBL** | | | | |
| CROES nomogram score | -0.351[a] | -0.027 | -0.003 | 0.017 |
| **Complication** | | | | |
| The Guy's stone score | 0.118[b] | 0.025 | 0.616 | 0.017 |
| Stone burden ($mm^2$) | 1.002[b] | 1.000 | 1.003 | 0.031 |

*OTT: Operation table time; SCR: Stone clearance rate; EBL: Estimated blood loss; coeff: coefficient; OR: odds ratio; CI: confidence interval;*

Linear regression coefficient test showed that only CROES nomogram was statistically significant with SCR, OTT and EBL (Table 3), (p = 0.017). Logistic regression analysis showed that each unit increased in GSS and stone burden parameters corresponds to an increase of 0.118 and 1.002 units in the risk of complications, respectively (Table 3).

## Discussion

It is important to predict complications and stone-free rates after PCNL operations in the preoperative period.[14, 15] The scoring system should be feasible, basic, uncomplex and rapid, as well as showing the SFR and the possibility of complica-

tions.[16] However, there is no consensus on which scoring system is better.

Some of prior studies on GSS showed considerable correlation in terms of SFR. In a study, Yarimoglu et al compared S.T.O.N.E. score systems with a total 160 patients, they found a considerable corelation between the GSS and SFR.[6] In the study conducted by Khan et al, the performance of the GSS and S.T.O.N.E. score systems were compared in predicting SFR after PCNL in 190 patients. The study found that GSS importantly correlated with SFR.[18]

Kumsar et al found Guy score insignificant in their study to predict SFR after PCNL.[19] In presented study no correlation between Guy's scores and SFR was found. The limited number of patients in groups GS 2, 3 and 4 may be effective on no correlation between GSS and SFR, contrary to the relationship found in previous studies. Singla et al compared the renal scoring nomograms to predict SFR after PCNL and found the CROES nomogram was significant.[20] In this study, S.T.O.N.E. and CROES nomograms significantly correlated with SFR.

Some variables of stone characteristics and patient anatomy that predict SFR and complication probability after PCNL have been defined in various studies and various predictive models have been created.[21-23] In presented study, it was found that male gender, stone burden and the partial staghorn stones corelated with the SFR.

It is important to know the possibility of postoperative complications such as urinary extravasation, sepsis, colon or pleural injuries and to take precautions accordingly in the preoperative period.[17] Clavien classification was used to grade postoperative complications. In a study, Lai et al found significantly correlated S.T.O.N.E., CROES and Guy's scores in detecting post-operative complications.[14] To predict post-operative complications after PCNL, Singla et al compared renal scoring nomograms and found weak correlations.[20] In this study S.T.O.N.E. and CROES nomograms were significantly correlated with Clavien classified complications but Guy's score showed negative correlation with post-operative complications. However, categorically only S.T.O.N.E. scoring system showed correlation. According to Spearman correlation analysis results, GSS was only related to operating table time, S.T.O.N.E. scoring system correlated with both operating table time and SFR and the CROES scoring system correlated with operating table time, SFR and EBL.

Stone scoring systems are important to inform patients about SFR and complication risk before PCNL. CROES and S.T.O.N.E scoring systems were correlated with SFR both mean and categorically but no correlation was found with GSS. None of scoring systems were significantly correlated with Clavien classified complications, only the S.T.O.N.E. scoring system was categorically significant with presence of complication but not Clavien grading system. Although Guy's score showed a negative correlation with postoperative complications, when look at the logistic regression analysis, it was found to be significant together with stone burden. Presented results found that S.T.O.N.E. scoring system was more successful in showing postoperative complications and SFR.

## Conclusion

Only the S.T.O.N.E. score showed a significant relationship with the presence of complications ($p = 0.034$). Currently, none of the nomograms sufficiently predict the complications and SFR of complex stones such as staghorn, therefore, further large scale multicentre prospective studies are needed to develop new nomograms.

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## Conflict of interest

None.

# References

1. Thongprayoon C, Krambeck AE, Rule AD. Determining the true burden of kidney stone disease. Nat Rev Nephrol 2020 Dec;16(12):736-46.
2. Dave C, Shetty S, Faraj K, Howes DS, Sinert RH, Craig S, et al. Nephrolithiasis treatment & management [Internet]. [Cited: 27-Jun-2015]. Available at: http:// emedicine.medscape.com/article/437096-treatment.
3. Geraghty RM, Davis NF, Tzelves L, Lombardo R, Yuan C, Thomas K, et al. Best practice in interventional management of urolithiasis: an update from the European Association of Urology Guidelines Panel for Urolithiasis 2022. Eur Urol Focus 2023 Jan;9(1):199-208.
4. Cracco CM, Scoffone CM. Endoscopic combined intrarenal surgery (ECIRS) - Tips and tricks to improve outcomes: A systematic review. Turk J Urol 2020 Nov;46(-Supp. 1):S46-S57.
5. Yang T, Liu S, Hu J, Wang L, Jiang H. The evaluation of risk factors for postoperative infectious complications after percutaneous nephrolithotomy. Biomed Res Int 2017;2017:4832051. doi: 10.1155/2017/4832051.
6. Yarimoglu S, Bozkurt IH, Aydogdu O, Yonguc T, Sefik E, Topcu YK, et al. External validation and comparison of the scoring systems (S.T.O.N.E, GUY, CROES, S-ReSC) for predicting percutaneous nephrolithotomy outcomes for staghorn stones: A single center experience with 160 cases. Kaohsiung J Med Sci 2017 Oct;33(10):516-22.
7. Al Adl AM, Mohey A, Abdel Aal A, Abu-Elnasr HAF, El Karamany T, Noureldin YA. Percutaneous nephrolithotomy outcomes based on S.T.O.N.E., GUY, CROES, and S-ReSC scoring systems: the first prospective study. J Endourol 2020 Dec;34(12):1223-8.
8. Kumar U, Tomar V, Yadav SS, Priyadarshi S, Vyas N, Agarwal N, et al. STONE score versus Guy's Stone Score - prospective comparative evaluation for success rate and complications in percutaneous nephrolithotomy. Urol Ann 2018;10:76-81.
9. Ketsuwan C, Kijvikai K, Kongchareonsombat W, Sangkum P, Rongthong S, Leenanupunth C. A comprehensive comparison of Guy's stone score, CROES nomogram, S.T.O.N.E. nephrolithometry, and the Seoul renal stone complexity scoring system in predicting perioperative outcomes after percutaneous nephrolithotomy. J Med Assoc Thai 2020;103:762-6.
10. Vicentini FC, Serzedello FR, Thomas K, Marchini GS, Torricelli FCM, Srougi M, et al. What is the quickest scoring system to predict percutaneous nephrolithotomy outcomes? A comparative study among S.T.O.N.E score, guy's stone score and croes nomogram. Int Braz J Urol 2017 Nov-Dec;43(6):1102-9.
11. de la Rosette JJ, Opondo D, Daels FP, Giusti G, Serrano A, Kandasami SV, et al; CROES PCNL Study Group. Categorisation of complications and validation of the Clavien score for percutaneous nephrolithotomy. Eur Urol 2012 Aug;62(2):246-55.
12. Tiselius HG, Andersson A. Stone burden in an average Swedish population of stone formers requiring active stone removal: how can the stone size be estimated in the clinical routine? Eur Urol 2003 Mar;43(3):275-81.
13. Labadie K, Okhunov Z, Akhavein A, Moreira DM, Moreno-Palacios J, Del Junco M, et al. Evaluation and comparison of urolithiasis scoring systems used in percutaneous kidney stone surgery. J Urol 2015 Jan;193(1):154-9.
14. Lai S, Jiao B, Jiang Z, Liu J, Seery S, Chen X, et al. Comparing different kidney stone scoring systems for predicting percutaneous nephrolithotomy outcomes: A multicenter retrospective cohort study. Int J Surg 2020 Sep;81:55-60.
15. Türk C, Petrik A, Sarica K, Seitz C, Skolarikos A, Straub M, et al. EAU guidelines on interventional treatment for urolithiasis. Eur Urol 2016;69:475-82.
16. Thomas K, Smith NC, Hegarty N, Glass JM. The Guy's stone score – grading the complexity of percutaneous nephrolithotomy procedures. Urology 2011;78:277–81.
17. Michel MS, Trojan L, Rassweiler JJ. Complications in percutaneous nephrolithotomy. Eur Urol 2007;51:899-906; discussion 906.
18. Khan N, Nazim SM, Farhan M, Salam B, Ather MH. Validation of S.T.O.N.E nephrolithometry and Guy's stone score for predicting surgical outcome after percutaneous nephrolithotomy. Urol Ann 2020 Oct-Dec;12(4):324-30.
19. Kumsar Ş, Aydemir H, Halis F, Köse O, Gökçe A, Adsan O. Value of preoperative stone scoring systems in predicting the results of percutaneous nephrolithotomy. Cent European J Urol 2015;68(3):353-7.
20. Singla A, Khattar N, Nayyar R, Mehra S, Goel H, Sood R. How practical is the application of percutaneous nephrolithotomy scoring systems? Prospective study comparing Guy's Stone Score, S.T.O.N.E. score and the Clinical Research Office of the Endourological Society (CROES) nomogram. Arab J Urol 2017 Jan 12;15(1):7-16.
21. Jeong CW, Jung JW, Cha WH, Lee BK, Lee S, Jeong SJ, et al. Seoul National University Renal Stone Complexity Score for predicting stone-free rate after percutaneous nephrolithotomy. PLoS One 2013 Jun 18;8(6):e 65888. doi: 10.1371/journal.pone.0065888.
22. Mishra S, Sabnis RB, Desai M. Staghorn morphometry: a new tool for clinical classification and prediction model for percutaneous nephrolithotomy monotherapy. J Endourol 2012 Jan;26(1):6-14.
23. Mishra S, Sabnis RB, Desai MR. Percutaneous nephrolithotomy monotherapy for staghorn: paradigm shift for 'staghorn morphometry' based clinical classification. Curr Opin Urol 2012 Mar;22(2):148-53.