Endourology and Stones

Comparison of Scoring Systems in Pediatric Mini-Percutaneous Nephrolithotomy

Mehmet Mazhar Utangac, Abdulkadir Tepeler, Mansur Daggulli, Muhammed Tosun, Onur Dede, and Abdullah Armagan

OBJECTIVE To apply urolithiasis scoring systems to the pediatric miniperc procedure and to compare their predictive capability for postoperative outcomes.

MATERIALS AND METHODS Records from 2 referral centers of patients under 18 years of age who had the miniperc procedure between 2010 and 2015 were retrospectively investigated. All patients included in the study were graded by the same surgeon according to Guy's and Clinical Research Office of the Endourological Society (CROES) scoring systems using preoperative imaging methods. Patient demographics and outcomes were compared according to the complexity of the procedure as graded by each scoring system.

RESULTS The mean age of the 97 patients was 7.1 ± 5.2 (1-17) years. The mean stone burden and number were 388.4 ± 233.9 mm^2 and 1.5 ± 1.3, respectively. The mean procedure, fluoroscopy, and hospitalization times were 78.2 ± 32.8 minutes, 144.8 ± 84.3 seconds, and 4.1 ± 2.8 days, respectively. The mean hematocrit drop was calculated as 2.2 ± 2.2. The mean scores were 1.7 ± 1.0 and 259.9 ± 50.6 for Guy's and CROES scoring systems, respectively. In the multivariate analysis, stone-free status was found to be associated with Guy's (r: −0.464, *p*: .000) and CROES (r: 0.490, : 0.000) scoring systems and stone burden (r: −0.161, *p*: .041). In the analysis of factors related to complication, Guy's score was identified as an independent predictor of complication (*p*: .02, odds ratio: 1.9, 95% confidence interval 1.097-3.319).

CONCLUSION According to our results, using Guy's and CROES scoring systems, stone-free ratios after percutaneous nephrolithotomy may be predicted preoperatively. In addition, Guy's system is a predictor of postoperative complication rate. UROLOGY ■■: ■■–■■, 2016.

In pediatric patients, percutaneous nephrolithotomy (PNL) is commonly chosen as a first-line treatment for renal stones larger than 2 cm due to its safety and efficiency.[1] Although adult-size instruments were previously employed, due to technological advances resulting from miniaturized surgical instruments, surgical intervention as a method to treat pediatric stones has been further developed and altered.[2] With the application of adult-size instruments in pediatric cases, increased complication rates were observed after PNL.[3] To reduce complications and expand the use of PNL, the "miniperc" technique has been developed for treatment of pediatric calculi.[4]

The grading systems were developed to precisely predict the operation results during the preoperative period, to recognize complex cases and to refer the challenging cases to more experienced centers. Different scoring systems were defined for different surgical approaches, and 3 popular scoring systems were defined for PNL in the literature. In previous studies, these scoring systems have been reported to predict the operation results.[5-7]

Initially, these scoring systems were developed for adult patients. Although the PNL procedure is not technically different in adults compared with pediatric patients, PNL is regarded as a more difficult procedure in pediatric cases due to the smaller size and more fragile structure of the kidneys. Among the scoring systems, only the S.T.O.N.E. nephrolithometry system has been applied in children.[8] No previous studies have compared these scoring systems in children.

MATERIALS AND METHODS

After obtaining local ethics committee approval, records from 2 referral centers of patients under 18 years of age who had the

Financial Disclosure: *The authors declare that they have no relevant financial interests.*

From the Department of Urology, Faculty of Medicine, Dicle University, Diyarbakir, Turkey; and the Department of Urology, Faculty of Medicine, Bezmialem Vakif University, Istanbul, Turkey

Address correspondence to: Abdulkadir Tepeler, M.D., Faculty of Medicine, Department of Urology, Bezmialem Vakif University, Istanbul, Turkey. E-mail: akadirtepeler@yahoo.com

Submitted: February 16, 2016, accepted (with revisions): March 22, 2016

http://dx.doi.org/10.1016/j.urology.2016.03.038
0090-4295

miniperc procedure between 2010 and 2015 were retrospectively investigated. Patient demographics, including age, sex, history of previous treatment, stone location and burden, presence of anatomical abnormality, and perioperative variables (operation, fluoroscopy, and hospitalization time, access site, location, and success and complication rates), were collected. The approval forms for the procedure were taken from all patients or parents.

All patients were evaluated with laboratory tests (serum creatinine, electrolytes, coagulation profile, urinalysis, complete blood count, and urine culture) and imaging methods [plain radiography of kidneys, ureters, and bladder (KUB); renal ultrasonography; intravenous urography; or computed tomography (CT)]. Stone surface area was assessed using the following formula: length × width × 3.14 × 0.25 as previously described in the literature.[9]

Measurements and Patient Grading

All patients included in the study were graded by the same surgeon according to the Guy and Clinical Research Office of the Endourological Society (CROES) scoring systems using preoperative imaging methods as defined previously in the literature. For the Guy scoring system, patients were classified into grade 1, 2, 3, or 4 depending on the stone number, location, and staghorn status and anatomical abnormality.[5] For the CROES system, the patients were divided into 4 groups using the scores reported by Smith et al.[6] Patient demographics and outcomes were compared according to the complexity of the procedure as graded by each scoring system.

Surgical Technique

All the procedures were performed under general anesthesia by urologists experienced with PNL. A 5Fr ureter catheter was inserted up to the collecting system in the lithotomy position. Later, the patient was positioned in prone. With a retrograde injection of opaque medium, the calyceal system was monitored completely, and, consequently, the entrance calyx was determined. Entrance to the renal collecting system was performed using the 18G access needle under the guidance of fluoroscopy. The tract was dilated over a hydrophilic guide wire inserted into the collecting system using Amplatz dilators up to 14-20Fr. Stone disintegration was performed with the Ho:yttrium aluminum garnet laser through a rigid nephroscope (9.5, 12 or 17Fr nephroscope). An additional tract was created when required. At the end of the operation, stone-free status was evaluated with endoscopic and fluoroscopic imaging. A nephrostomy tube was inserted depending on surgeon preference regarding the presence of bleeding, residual stone, and collecting system perforation.

On postoperative day 1, the patients were evaluated with laboratory tests and KUB. The urethral catheter was removed on the 1st day, the nephrostomy was removed on the 2nd or 3rd day, and the patients who did not have any complications were discharged. Stone-free status was assessed with KUB and US in the 4th week control visit. Success was defined as the lack of residual fragments.

Statistical Analysis

Statistical analysis was performed by SPSS software version 22 (SPSS Inc, Chicago, IL). Numerical variables are presented as means ± standard deviation. Categorical variables are described as absolute number and percent frequency. Independent sample (t) test and chi-square tests were used to analyze continuous and categorical variables, respectively. Multivariate logistic regression analysis was used to identify independent predictors for postoperative outcomes. Pearson correlation analysis was done for correlation.

The area under the curve, calculated by receiver operating characteristic curve, was used to assess the predictive ability of the independent predictors. All *p*-values were 2-tailed, with statistical significance set at 0.05 and confidence intervals were calculated at the 95% level.

RESULTS

The mean age of the 97 patients (48 boys and 49 girls) was 7.1 ± 5.2 (1-17) years. The mean stone burden and number were 388.4 ± 233.9 mm^2 and 1.5 ± 1.3, respectively. Staghorn stone (partial and complete) ratio was 24.7%. The patient demographics and perioperative data are summarized in Table 1.

The mean procedure, fluoroscopy, and hospitalization times were 78.2 ± 32.8 minutes, 144.8 ± 84.3 seconds, and 4.1 ± 2.8 days, respectively. The mean hematocrit drop was calculated as 2.2 ± 2.2. The mean tract number was calculated as 1.0 ± 0.2 (1-2). Stone-free status was achieved in 72 of the cases (74.2%) after the first miniperc session. After additional treatment was applied, 89 patients (91.7%) were rendered as stone-free. The mean scores were 1.7 ± 1.0 and 259.9 ± 50.6 for the Guy and CROES scoring systems, respectively.

Stone location, stone complexity, stone burden, the CROES and Guy scoring systems, and scopy time were statistically associated with the procedure success rate (*p*: .001, *p*: .000, *p*: .001, *p*: .000. *p*: .000, *p*: .001, respectively). In the multivariate analysis, stone-free status was found to be associated with the Guy and CROES scoring systems and stone burden. Whereas Guy score (r: −0.464, *p*: .000) and stone burden (r: −0.161, *p*: .041) were negatively correlated with success rate, a positive correlation between the CROES score and the success rate (r: 0.490, *p*: .000) was detected. Figure 1 presents the area under the curve and receiver operating characteristic curves. The CROES scoring system had the highest accuracy for predicting the success of miniperc in this pediatric population.

In our series, a total of 12 (12.4%) complications occurred postoperatively. In the assessment of factors related to complication rate, presence of hydronephrosis (*p*: .03), Guy's score (*p*: .01), scopy time (*p*: .03), duration of hospitalization (*p*: .01) was found to be predictors. On multivariate analysis, only Guy's score was identified as an independent predictor of complication [*p*: .02, odds ratio (OR): 1.9, 95% confidence interval (CI) 1.097-3.319].

COMMENT

Urinary stone disease is a rare condition in pediatric patients with a prevalence of 2%.[10] Minimally invasive methods are preferred treatment options because the recurrence risk of stones is high in the pediatric group. PNL, in experienced hands, can be performed confidently and efficiently, with a high stone-free rate and low additional

Table 1. Comparison of patients' demographics, perioperative variables, and scores according to the procedure outcome

	Not Stone-free	Stone-free	Overall	*P*-value
N (%)	25 (25.8)	72 (74.2)	97	
Gender, n (%)				.524
Boy	12 (48)	36 (50)	48 (49.5)	
Girl	13 (52)	36 (50)	49 (50.5)	
Age, mean ± SD	8.4 ± 6.3	6.6 ± 4.7	7.1 ± 5.2	.136
Stone burden (mean ± SD)	514.5 ± 236.3	344.8 ± 217.9	388.4 ± 233.9	.001
Side, n (%)				.595
Right	16 (64)	46 (63.9)	62 (63.9)	
Left	9 (36)	26 (36.1)	35 (36.1)	
Mean BMI (kg/m^2)	21.6 ± 4.5	21.5 ± 4.0	21.5 ± 4.1	.888
Stone number (n)	1.9 ± 1.1	1.4 ± 1.3	1.5 ± 1.3	.086
Stone location				.001
Upper pole	6 (24)	21 (29.2)	27 (27.8)	
Middle pole	0 (0)	1 (1.4)	1 (1)	
Lower pole	1 (4)	0	1 (1)	
Renal pelvis	2 (8)	33 (45.8)	35 (36.1)	
Multiple locations	16 (64)	17 (23.6)	33 (34)	
Stone complexity				.000
Yes	16 (64)	17 (23.6)	33 (34)	
No	9 (36)	55 (76.4)	64 (66)	
Partial or complete staghorn, n (%)				.333
Partial staghorn	7 (43.5)	9 (56.25)	16	
Complete staghorn	5 (37.5)	3 (62.5)	8	
Hydronephrosis, n (%)				.496
Yes	16 (64)	48 (66.7)	64 (66)	
No	9 (36)	24 (33.3)	33 (34)	
CROES score (mean ± SD)	221.4 ± 43.9	272.1 ± 45.9	259.9 ± 50.6	.000
Guy's score (mean ± SD)	2.6 ± 0.9	1.4 ± 0.8	1.7 ± 1.0	.000
Operation time (minutes)	87.8 ± 33.3	75.2 ± 31.4	78.2 ± 32.8	.110
Scopy time (second)	191.2 ± 108.5	128.0 ± 67.1	144.8 ± 84.3	.001
Access number (n)	1.0 ± 0.2	1.0 ± 0.1	1.0 ± 0.2	.764
Hematocrit drop (%)	2.2 ± 2.3	2.2 ± 2.2	2.2 ± 2.2	.991
Hospitalization (day)	3.8 ± 2.3	4.2 ± 3.0	4.1 ± 2.8	.554
Complication, n (%)	4 (16)	8 (11.1)	12 (12.4)	.372

BMI, body mass index; CROES, Clinical Research Office of the Endourological Society; SD, standard deviation.

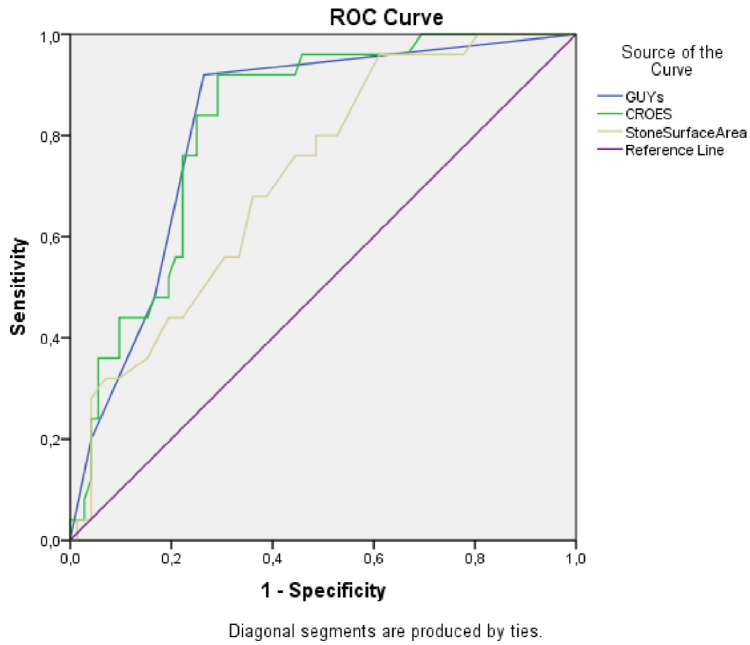

Figure 1. Receiver operating characteristic curves of Clinical Research Office of the Endourological Society and Guy stone scores.

treatment requirements.[11,12] With the increased experience of urologists and miniaturized surgical instruments, PNL has become a standard treatment in pediatric patients.

In pediatric patients, the renal parenchyma is quietly fragile and has a relatively small collecting system surface area; therefore, performing the PNL procedure with adult-size instruments may not be optimal. In a study by Desai et al,[13] the intraoperative bleeding rate and hemoglobin drop were found to be associated with tract size in children; therefore, to prevent parenchymal damage and bleeding complications, the usage of miniaturized instruments (miniperc) is recommended in children. In our study, the tract diameter utilized was between 14 and 20 Fr.

With the widespread application of PNL, several studies have been conducted to predict the postoperative outcomes preoperatively. Many factors related to the patient, stone, and procedure that may affect the results have been investigated by researchers.[14-19] As a result of these studies, several scoring systems were developed (Guy, CROES, and S.T.O.N.E.).[5-7] These scoring systems allow the evaluation of complex cases during the preoperative period to refer the patients to the appropriate referral centers. Furthermore, they provide the standardization of the PNL results to compare with other series.[5-7] In recent years, the investigators advise the use of scoring systems that can predict the PNL results with the help of preoperative imaging techniques.[5-7,20-23]

In the Guy scoring system, with the evaluation of stone localization, staghorn status, and anatomical anomalies detected with imaging techniques, the patients are graded between grades 1 and 4.[5] In the first study, the grading was performed with KUB, whereas later studies using CT and intravenous urography images were also reported.[20] In contrast, the CROES scoring system includes the radiological findings (stone localization, and burden and staghorn status) along with many variables, such as the annual PNL case volume of the center and history of previous treatment methods (eg, ureteroscopy, shockwave lithotripsy, open surgery, or PNL).[6] The Guy scoring system is reproducible and easily available in clinical practice, whereas the CROES scoring system is more difficult to perform because this method includes more comprehensive data.

The S.T.O.N.E. scoring system is the abbreviation of the initial letters of 5 parameters (stone size, tract length, obstruction, number of calyces retained, and stone density).[7] Preoperative CT is mandatory to measure stone density and tract length. Because CT was not performed in all pediatric patients due to the concern of high radiation exposure, we did not assess the S.T.O.N.E. scoring system in this study.

The available scoring systems were developed and used in adults. In a study by Thomas et al, the Guy scoring system was determined to be correlated with the stone-free rate but not the complication rates. In this study, the researchers reported that the Guy score properly predicts the stone-free ratio after PNL.[5] In a study by Vicentini et al, the Guy score was determined to be highly effective in predicting the success and complication rates of PNL.[20] In a study by Sinha et al, the Guy score was defined as an excellent tool to predict the stone-free rates in the preoperative period.[23] Labadie et al compared the Guy, S.T.O.N.E., and CROES scoring systems and determined that all 3 scores had similar capabilities in predicting PNL results.[21] In a large series of studies, Bozkurt et al compared the Guy and CROES nomograms and found that both scores were similar in predicting stone-free rates after PNL.[22] These scoring systems were used in pediatric age groups in only 2 studies.[8,24] First, in a study by Doulian et al, the children with upper urinary tract stones were graded with the S.T.O.N.E. scoring system.[8] The researchers reported that this scoring system may predict the procedure complexity, hospitalization period, and complication rate and suggested that system, initially adopted for adults, should be modified because of the pediatric renal anatomy. In another study, Goyal et al determined that stone size, complexity, Guy score, tract size, access number, and operation time were significantly associated with complications.[24] However, in the multivariate analysis, only the operation time was defined as an independent risk factor for complications of the procedure.

To our knowledge, our study is the first to compare the capability of the Guy and CROES scoring systems to predict miniperc outcomes in the pediatric group. In this study, we found that both the Guy and CROES scoring systems and stone burden are important determinants of the success of miniperc. In our study, the CROES score has the highest accuracy in predicting miniperc success. We also detected that only Guy's score was identified as an independent predictor of complication.

Stone burden is an important parameter in all of the scoring systems, whereas in our study, stone surface area was also an important parameter affecting the outcome of the procedure. In the aforementioned scoring systems, stone burden, tract length, and case volume are the main parameters and calculated using the data of the adult cases. Besides these factors, we believe that the age of the pediatric case should be another factor making the PNL procedure more challenging. We believe that the complexity of the PNL procedure should be upgraded in pediatric cases because of relatively small collecting system, and small and mobile kidney. All of these facts reveal that those scoring systems should be modified for pediatric cases.

The retrospective and multi-centered nature of this study is the primary limitation of the study. Nevertheless, this study is the first to evaluate the role of the Guy and CROES scoring systems in the prediction of PNL success in patients under the 18 years of age.

CONCLUSION

In this study, we have determined that the Guy and CROES scoring systems are useful tools to predict miniperc outcomes in pediatric population. According to our results, using Guy's and CROES scoring systems, stone-free ratios after PNL may be predicted preoperatively. Guy's score is found to be an important predictor of postoperative complication. Further studies involving a larger number of patients are warranted.

References

1. Tekgül S, Dogan HS, Hoebeke P, et al. Guidelines on Paediatric Urology. European Society for Paediatric Urology. European Association of Urology 2016.
2. Zeng G, Zhao Z, Zhao Z, et al. Percutaneous nephrolithotomy in infants: evaluation of a single-center experience. *Urology*. 2012;80:408-411.
3. Unsal A, Resorlu B, Kara C, et al. Safety and efficacy of percutaneous nephrolithotomy in infants, preschool age, and older children with different sizes of instruments. *Urology*. 2010;76:247-252.
4. Helal M, Black T, Lockhart J, Figueroa TE. The Hickman peel-away sheath: alternative for pediatric percutaneous nephrolithotomy. *J Endourol*. 1997;11:171-172.
5. Thomas K, Smith NC, Hegarty N, et al. The Guy's stone score-grading the complexity of percutaneous nephrolithotomy procedures. *Urology*. 2011;78:277-281.
6. Smith A, Averch TD, Shahrour K, et al. A nephrolithometric nomogram to predict treatment success of percutaneous nephrolithotomy. *J Urol*. 2013;190:149-156.
7. Okhunov Z, Friedlander JI, George AK, et al. S.T.O.N.E. nephrolithometry: novel surgical classification system for kidney calculi. *Urology*. 2013;81:1154-1160.
8. Doulian S, Hasimu S, Jun D, et al. The application of S.T.O.N.E. nephrolithometry in pediatric patients with upper urinary tract calculi treated with mini-percutaneous nephrolithotomy. *Urolithiasis*. 2015;43:363-367.
9. 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;43:275-281.
10. Turney BW, Reynard JM, Noble JG, et al. Trends in urological stone disease. *BJU Int*. 2012;109:1082e7.
11. Straub M, Gschwend J, Zorn C. Pediatric urolithiasis: the current surgical management. *Pediatr Nephrol*. 2010;25:1239-1244.
12. Kapoor R, Solanki F, Singhania P, et al. Safety and efficacy of percutaneous nephrolithotomy in the pediatric population. *J Endourol*. 2008;22:637-640.
13. Desai MR, Kukreja RA, Patel SH, et al. Percutaneous nephrolithotomy for complex pediatric renal calculus disease. *J Endourol*. 2004;18:23-27.
14. Tefekli A, Ali Karadag M, Tepeler K, et al. Classification of percutaneous nephrolithotomy complications using the modified Clavien grading system: looking for a standard. *Eur Urol*. 2008;53:184-190.
15. de la Rosette JJ, Zuazu JR, Tsakiris P, et al. Prognostic factors and percutaneous nephrolithotomy morbidity: a multivariate analysis of a contemporary series using the Clavien classification. *J Urol*. 2008;180:2489-2493.
16. Turna B, Umul M, Demiryoguran S, et al. How do increasing stone surface area and stone configuration affect overall outcome of percutaneous nephrolithotomy? *J Endourol*. 2007;21:34-43.
17. Kukreja R, Desai M, Patel S, et al. Factors affecting blood loss during percutaneous nephrolithotomy: prospective study. *J Endourol*. 2004;18:715-722.
18. Zhu Z, Wang S, Xi Q, et al. Logistic regression model for predicting stone-free rate after minimally invasive percutaneous nephrolithotomy. *Urology*. 2011;78:32-36.
19. Mishra S, Sabnis RB, Desai M. Staghorn morphometry: a new tool for clinical classification and prediction model for percutaneous nephrolithotomy monotherapy. *J Endourol*. 2012;26:6-14.
20. Vicentini FC, Marchini GS, Mazzucchi E, et al. Utility of the Guy's stone score based on computed tomographic scan findings for predicting percutaneous nephrolithotomy outcomes. *Urology*. 2014;83:1248-1253.
21. Labadie K, Okhunov Z, Akhavein A, et al. Evaluation and comparison of urolithiasis scoring systems used in percutaneous kidney stone surgery. *J Urol*. 2015;193:154-159.
22. Bozkurt IH, Aydogdu O, Yonguc T, et al. Comparison of guy and clinical research office of the endourological society nephrolithometry scoring systems for predicting stone-free status and complication rates after percutaneous nephrolithotomy: a single center study with 437 cases. *J Endourol*. 2015;29:1006-1010.
23. Sinha RK, Mukherjee S, Jindal T, et al. Evaluation of stone-free rate using Guy's stone score and assessment of complications using modified Clavien grading system for percutaneous nephrolithotomy. *Urolithiasis*. 2015;43:349-353.
24. Goyal NK, Goel A, Sankhwar SN, et al. A critical appraisal of complications of percutaneous nephrolithotomy in paediatric patients using adult instruments. *BJU Int*. 2014;113:801-810.