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The Role of Scoring Systems in Predicting Surgical Success in Percutaneous Nephrolithotomy: Results from a Single Center

Perkütan Nefrolitotomi'de Skorlama Sistemlerinin Cerrahi Başarıyı Öngörmedeki Yeri: Tek Merkez Sonuçları

Emre Şam[1], **Ekrem Güner**[2]

[1] Department of Urology, University of Health Sciences, Regional Training and Research Hospital, Erzurum, Turkey
[2] Department of Urology, University of Health Sciences, Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Istanbul, Turkey

ÖZET

Amaç: Biz bu çalışmada, perkütan nefrolitotomide (PNL) en yaygın kullanılan modeller olan Guy's skoru, S.T.O.N.E skoru ve CROES nomogramının taşsızlığı öngörme etkinliklerini ve hangi modelin taşsızlığı daha başarılı öngördüğünü belirlemeyi amaçladık.

Gereç ve Yöntemler: Tersiyer akademik merkezimizde, 2009 ile 2018 tarihleri arasında böbrek taşı nedeniyle PNL uygulanan 18 yaşından büyük hastaların verileri retrospektif olarak değerlendirildi. İncelenen parametreler, hastaların demografik verileri, taşa ait özellikler, Guy's skoru, S.T.O.N.E. skoru, CROES nomogramı, operasyon süresi, transfüzyon oranı, hastanede kalış süresi ve taşsızlık idi. Taşsızlık açısından kestirim değerleri receiver operating characteristic (ROC) curve analizi kullanılarak belirlendi.

Bulgular: Çalışmaya toplam 200 hasta dahil edildi. Hastaların yaş ortalaması 43,7 ± 14,6 yıl idi. Hastaların ortalama taş skorları sırası ile şöyle idi: Guy's skoru: 2,11 ± 1,01, S,T,O,N,E skoru: 7,54 ± 1,73, CROES nomogramı: 194 ± 62,7, Taşsızlık oranı %66 olarak belirlendi. Taşsızlık sağlanamayan hastalarda taşsızlık sağlananlara göre Guy's skoru ve S.T.O.N.E skorunun anlamlı yüksek, CROES nomogramının ise anlamlı düşük olduğu belirlendi (sırasıyla p<0,001, p<0,001 ve p<0.001). Kestirim değeri ve eğri altındaki alan (AUC) sırasıyla Guy's skoru için 2,5 ve 0,770, S.T.O.N.E skoru için 7,5 ve 0,722 ve CROES nomogramı için 185 ve 0,843 idi.

Sonuç: PNL'de taşsızlığı öngörmede Guy's skoru, S.T.O.N.E skoru ile CROES nomogramı etkili modellerdir.

Anahtar Kelimeler: CROES nomogramı, Guy's skoru, perkütan nefrolitotomi, S.T.O.N.E skoru, taşsızlık

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Corresponding Author : Emre Şam, MD, Department of Urology, University of Health Sciences, Regional Training and Research Hospital, Erzurum, Turkey
Tel: +90 537 839 47 67 ***e-mail:*** emresam@yahoo.com
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ABSTRACT

Objective: In this study, we aimed to determine the effectiveness of Guy's score, S.T.O.N.E score, and CROES nomogram, the most widely used models in percutaneous nephrolithotomy (PNL) for predicting stone-free status, and to determine which model predicts stone-free status more successfully.

Materials and Methods: The data of patients older than 18 years of age who underwent PNL for kidney stones at our tertiary academic center between 2009 and 2018 were retrospectively analyzed. Examined parameters included the demographic data of patients, stone characteristics, Guy's score, S.T.O.N.E. score, CROES nomogram, surgical duration, transfusion rate, length of stay, and stone-free status. Prediction values for stone-free status were determined using receiver operating characteristic (ROC) curve analysis.

Results: A total of 200 patients were included in the study. The mean age of the patients was 43.7 ± 14.6 years. The mean stone scores of the patients were as follows: Guy's score: 2.11 ± 1.01; S.T.O.N.E. score: 7.54 ± 1.73; and CROES nomogram: 194 ± 62.7. The stone-free rate was determined to be 66%. The Guy's and S.T.O.N.E. scores were significantly higher, and the CROES nomogram was significantly lower in non-stone-free patients compared to stone-free patients (p<0.001, p<0.001, and p<0.001, respectively). The cut-off value and area under curve (AUC) were 2.5 and 0.770 for Guy's score, 7.5 and 0.722 for S.T.O.N.E score, and 185 and 0.843 for CROES nomogram, respectively.

Conclusion: Guy's score, S.T.O.N.E score, and CROES nomogram are effective models in predicting stone-free status in PNL.

Keywords: CROES nomogram, Guy's score, percutaneous nephrolithotomy, S.T.O.N.E score, stone-free

INTRODUCTION

The European Association of Urology recommends percutaneous nephrolithotomy (PNL) as the first choice of treatment for kidney stones larger than 2 cm (1). Developments in surgical technique and endoscopic equipment have resulted in an increase in stone-free status and a decrease in morbidity over the years (2). However, stone-free and complication rates vary between studies (3). Patient-centered treatment planning and the prominence of quality of life in patient management led to the development of various scoring systems and nomograms to predict treatment success prior to PNL. The most well-known ones are Guy's stone score (4), S.T.O.N.E. nephrolithometry (5), and the Clinical Research Office of the Endourological Society (CROES) nomogram (6).

Guy's score divides patients into four classes (Grade 1-4) based on stone complexity and pelvicalyceal anatomy (4). The S.T.O.N.E. score is based on these 5 variables: Stone size, tract length, obstruction, number of involved calices, and essence (stone density). Scoring based on these variables determines categorization into three risk groups (least complex ≤5 points, moderate 6-8 points, and most complex ≥8) (5). The CROES nomogram calculates a score ranging from 0 to 350 based on the variables of stone burden, stone location, prior treatments, presence of staghorn, number of stones (single/multiple), and number of cases per year (6). Higher Guy's score and S.T.O.N.E. score indicate an increase in complexity and a decrease in the stone-free rate, whereas, on the CROES nomogram, high scores indicate a decrease in complexity and an increase in the stone-free rate (4–6).

Although the effectiveness of these three models in predicting stone-free status has been shown in studies, their superiority to each other is not known, and there is no gold standard model that predicts stone-free status (7). In this study, we aimed to determine the effectiveness of Guy's score, S.T.O.N.E score, and CROES nomogram and to determine which model predicts stone-free status more successfully.

MATERIAL AND METHODS

After approval by our hospital's local ethics committee (2019/407) and obtaining patient informed consent forms, the data of patients who underwent PNL for kidney stones in our tertiary academic center between 2009 and 2018 were retrospectively analyzed. All female and male patients older than 18 years of age were included in the study. Patients who received anticoagulant or antithrombotic therapy, underwent bilateral PNL, had a nephrostomy tube prior to surgery, and had missing data were excluded from the study. Our study was conducted in accordance with the ethical standards specified in the 1964 Declaration of Helsinki and later amendments.

All patients underwent non-contrast computed tomography (NCCT) and intravenous pyelography as part of their treatment plan. All patients had a preoperative sterile urine culture, and intravenous cefuroxime axetil prophylaxis was started one hour before the operation and continued for three days. Sterile urine cultures were obtained by giving appropriate antibiotic treatment to patients with growth in urine cultures.

The parameters examined included patient demographics, American Society of Anesthesiologists (ASA) score, stone characteristics (stone burden, stone density), Guy's score, S.T.O.N.E. score, CROES nomogram, surgical duration, transfusion rate, length of stay, and stone-free status. The stone burden was calculated with NCCT using the $length_{max}*width_{max}*3.14*0.25$ formula (8). In the presence of multiple stones, the total stone burden was calculated by separately calculating the stone burden of each stone and adding them together. Stone density (HU) was calculated with the region of interest encompassing the entire stone surface in axial NCCT images displaying the largest stone diameter. Partial staghorn was defined as the extension of the renal pelvis stone to at least two calyces, and staghorn was defined as the extension to all calyces. The surgical duration was calculated as the duration between the initial puncture and the insertion of a 14-F nephrostomy tube.

Surgical Technique

Under general anesthesia, a 4-6 F ureteral catheter was inserted into the ipsilateral kidney through a 22 F cystoscope (Karl Storz, Tuttlingen, Germany) in the lithotomy position. A 16-F Foley catheter was inserted. The ureteral catheter was fixed to the Foley catheter, and the patient was placed in the prone position. After cleaning the surgical area with an antiseptic solution, a sterile surgical drape set was used to cover the patient, along with a camera and C-arm fluoroscopy. Retrograde pyelography was used to determine the appropriate calyx, and monoplanar access was achieved using an 18-G percutaneous trocar needle. After inserting the 0.035-inch polytetrafluoroethylene-coated sensor guidewire (Boston Scientific, Massachusetts, USA) into the pelvicalyceal system, the tract was dilated, and a 30-F amplatz sheath (Boston Scientific, Massachusetts, USA) was placed. The pelvicalyceal system was accessed with a 26-F rigid nephroscope (Karl Storz, Tuttlingen, Germany) and the stones were fragmented with a pneumatic lithotripter (Vibrolith, Elmed, Ankara, Turkey). Following the removal of the fragments, the presence of residual fragments was determined using fluoroscopy, endoscopy, and an antegrade nephrostogram. A 16-F flexible nephroscope (Karl Storz, Tuttlingen, Germany) was used in cases where it was necessary. A 14-F nephrostomy tube was inserted in all patients. When necessary, an antegrade DJ stent was placed at the surgeon's discretion.

The nephrostomy tube was clamped and removed once the patient was pain-free and had produced urine of a clear color. In the first month postoperatively, stone-free status was determined using plain radiography and/or urinary system ultrasonography in cases of opaque stones and urinary system ultrasonography in cases of non-opaque stones. NCCT was used if stone-free status could not be determined with plain radiography/urinary system ultrasonography. The absence of stones or the presence of asymptomatic, non-obstructive, and non-infectious, clinically insignificant residual fragments smaller than 4 mm were considered stone-free.

Statistical Analysis

Categorical variables were presented as numbers and percentages, and continuous variables as mean and standard deviation. The normal distribution of continuous variables was assessed with the Shapiro-Wilk test. Student's t-test was used to compare the means of two normally distributed independent groups, while the Mann-Whitney U test was used to compare the means of two non-normally distributed independent groups. The percentage of categorical variables was compared with the Pearson Chi-Square. Prediction values for stone-free status were determined using receiver operating characteristic (ROC) curve analysis. When $P < 0.05$ was detected, it was deemed statistically significant.

RESULTS

A total of 200 patients were included in the study. While the mean age of the patients was 43.7 ± 14.6 years, 130 of the patients were male and 70 were female. The mean stone burden was 552 ± 461 mm^2. The mean stone density was 983 ± 327 HU. The mean surgical duration was 82.2 ± 12.3 minutes. The mean stone scores were as follows: Guy's score: 2.11 ± 1.01; S.T.O.N.E. score: 7.54 ± 1.73; and CROES nomogram: 194 ± 62.7. The mean length of stay was 3.65 ± 1.63 days. The stone-free rate was determined to be 66%. The data and clinical characteristics of the patients are shown in Table 1.

There was no significant difference between stone-free and non-stone-free patients in parameters such as age, body mass index (BMI), gender, ASA score, or laterality. Stone burden, transfusion rate, and length of stay were found to be significantly higher in patients who were non-stone-free than those who were stone-free (p<0.001, p<0.043, and p<0.001, respectively). It was determined that Guy's score and S.T.O.N.E. score were significantly higher and the CROES nomogram was significantly lower in patients who were non-stone-free compared to those who were stone-free (p<0.001, p<0.001, and p<0.001, respectively). The comparison of stone-free and non-stone-free patients is presented in Table 2.

The ROC curve was used to determine cut-off values and area under curve (AUC) analysis for each variable. The cut-off value and AUC were 2.5 and 0.770 for Guy's score, 7.5 and 0.722 for S.T.O.N.E score, and 185 and 0.843 for CROES nomogram, respectively (Figure 1).

Table 1. Demographic data and clinical characteristics

Number of patients	200
Mean age ± SD, year	43.7 ± 14.6
Mean BMI ± SD, kg/m^2	23.5 ± 2.41
Gender, n(%)	
Male	130 (65.0)
Female	70 (35.0)
ASA, n(%)	
ASA 1	71 (35.5)
ASA 2	115 (57.5)
ASA 3	14 (7.0)
Laterality, n(%)	
Right	84 (42.0)
Left	116 (58.0)
Mean stone burden ± SD, (mm^2)	552 ± 461
Mean stone density ± SD, (HU)	983 ± 327
Mean Guy's score ± SD	2.11 ± 1.01
Mean S.T.O.N.E score ± SD	7.54 ± 1.73
Mean CROES nomogram ± SD	194 ± 62.7
Mean surgical duration ± SD, min	82.2 ± 12.3
Transfusion rate, n (%)	18 (9.0)
Mean LOS ± SD, day	3.65 ± 1.63
SFR, n(%)	132 (66.0)

SD:standart deviation; BMI:body mass index; ASA:American Society of Anaesthesiology; HU:hounsfield unit; LOS:length of stay; SFR:stone-free rate

Table 2. Comparison of patients' characteristic according to stone-free status

Variables	Stone-free	Non-stone free	P value
Number of patients	132	68	
Mean age ± SD, year	43.4 ± 15.2	44.4 ± 13.6	0.656*
Mean BMI ± SD, kg/m^2	23.5 ± 2.44	23.6 ± 2.37	0.790*
Gender, n(%)			
Male	82 (62.1)	48 (70.6)	0.234#
Female	50 (37.9)	20 (29.4)	
ASA, n(%)			
ASA 1	49 (37.1)	22 (32.4)	
ASA 2	71 (53.8)	44 (64.7)	0.162#
ASA 3	12 (9.1)	2 (2.9)	
Laterality, n(%)			
Right	56 (42.4)	28 (41.2)	0.866#
Left	76 (57.6)	40 (58.8)	
Mean stone burden ± SD, (mm^2)	426 ± 268	799 ± 632	<0.001**
Mean stone density ± SD, (HU)	968 ± 340	1012 ± 302	0.368*
Mean Guy's score ± SD	1.78 ± 0.92	2.73 ± 0.89	<0.001*
Mean S.T.O.N.E score ± SD	7.13 ± 1.65	8.33 ± 1.60	<0.001*
Mean CROES nomogram ± SD	218 ± 54.1	147 ± 50.9	<0.001*
Mean surgical duration ± SD, min	81.2 ± 11.5	84.1 ± 13.6	0.116*
Transfusion rate, n (%)	8 (6.1)	10 (14.7)	0.043#
Mean LOS ± SD, day	3.39 ± 1.46	4.16 ± 1.84	0.004**

SD:standart deviation; BMI:body mass index; ASA:American Society of Anaesthesiology; HU:hounsfield unit; LOS:length of stay; * Independent Sample t test; **Mann-Whitney U test; #Pearson Chi-Square

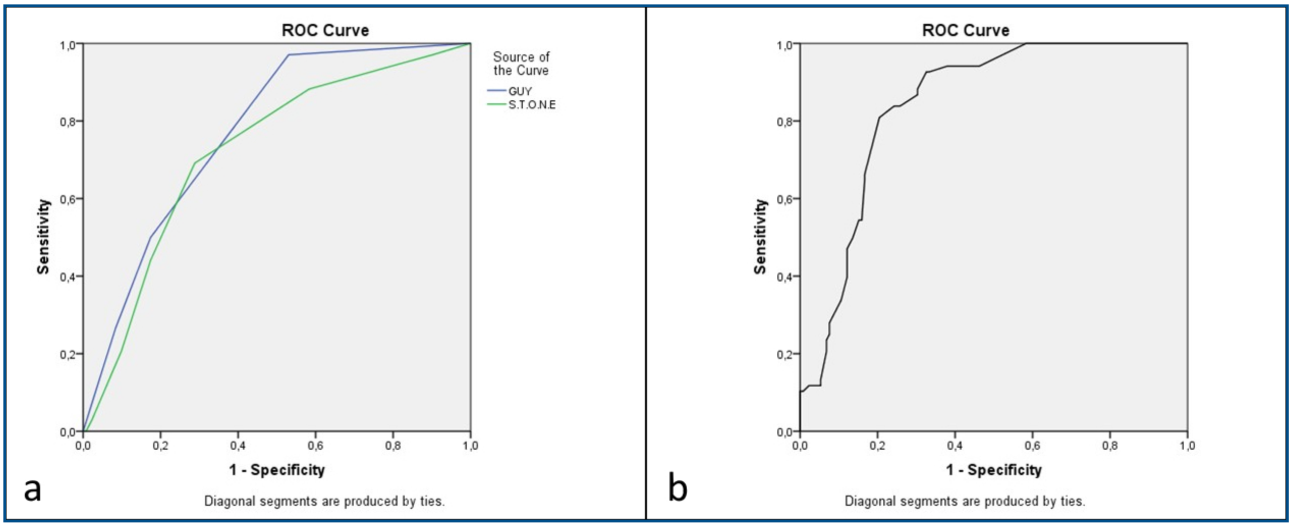

Figure 1. ROC curve for Guy's score, S.T.O.N.E score and CROES nomogram in predicting stone-free status. AUC, area under the curve (a) AUC value: 770 for Guy's score; 722 for S.T.O.N.E score, Cut-off value: 2.5 for Guy's score, 7.5 for S.T.O.N.E score (b) AUC value: 843, Cut-off value: 185 for CROES nomogram

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DISCUSSION

The models utilized in PNL make significant contributions such as predicting surgical success and the risk of complications, planning surgical strategies, providing better counseling to the patient, and comparing the results of different institutions (9). They can also help determine which patients should be referred to specialized centers and help plan training (4). In our study, we aimed to determine the effectiveness of the most widely used models in predicting stone-free status and which model predicts stone-free status more accurately. As a result of the ROC analysis, we determined that all three models were effective in predicting stone-free status.

In a study by Thomas et al., who first defined Guy's score, it was determined that Guy's score was the only independent factor predicting the stone-free ratio (P = 0.010) (4). In a high-volume study conducted with 1000 patients who underwent PNL, De Souza Melo et al. reported that the success rate of PNL was 87.9% in patients with a Guy's score of 1, while it was 24.3% in patients with a Guy's score of 4 (2). Ingimarsson et al. determined that the inter-rater concordance of Guy's score was good ($\kappa = 0.72$) and 78% of the cases were categorized the same by both raters (10). Vicentini et al. determined that Guy's score (27.5 seconds) implementation time was significantly shorter than the S.T.O.N.E score (300.6 seconds) and the CROES nomogram (213.4 seconds) implementation times (11). In accordance with the literature, we determined in our study that Guy's score was significantly higher in non-stone-free patients compared to stone-free patients. In addition, we believe that Guy's score is superior to others since it is the most studied model and is simple to implement in clinical practice.

In the study of Okhunov et al., who first defined the S.T.O.N.E score, they found that the S.T.O.N.E score was significantly higher in non-stone-free patients compared to stone-free patients (9.7 vs 6.8, p=0.002, respectively) (5). In a study conducted by Farhan et al. with 107 patients who underwent PNL, it was determined that the S.T.O.N.E score was significantly higher in non-stone-free patients compared to stone-free patients (8.14 vs 7.24, respectively, p=0.02) (12). In a study by Akhevien et al. conducted with 122 patients who underwent PNL, it was reported that patients with lower S.T.O.N.E scores had significantly higher treatment success (p = 0.002) (13). In a prospective study performed by Danis et al. in 120 patients who underwent PNL, it was determined that S.T.O.N.E score was significant in predicting stone-free status and that S.T.O.N.E score was correlated with surgical duration, estimated blood loss, fluoroscopy time, hospital stay, and number of punctures (14). In our study, we determined that the S.T.O.N.E. score was significantly higher in patients who were non-stone-free than those who were stone-free, in line with the literature.

In the study by Smith et al., who first described the CROES nomogram, the CROES nomogram was created with six variables predicting stone-free status, and stone burden was found to be the best predictor (6). In a study conducted by Sfoungaristos et al. involving 176 patients who underwent PNL, it was determined that the CROES nomogram was an independent predictor of PNL success (15). In accordance with the literature, we determined in our study that the stone burden was significantly higher in non-stone-free patients than in those who were stone-free, and the CROES nomogram was significantly lower.

There are also studies evaluating the three models. In a prospective study involving 48 patients who underwent PNL, Singla et al. determined that all three models were equally effective at predicting stone-free status (16). In a study by Labadie et al. conducted with 246 patients who underwent PNL, it was determined that all three models were significantly associated with stone-free status (17). In a study by Ozgor et al. that compared the three models in obese patients, it was found that Guy's score and the CROES nomogram were independent factors in predicting PNL success, and the S.T.O.N.E. score was not correlated with PNL success (18). In our study, we determined that all three models were effective in predicting stone-free status in accordance with the literature.

Our study has limitations. Firstly, it was designed as a retrospective study. This may have caused selection bias. Secondly, the effectiveness of existing models in predicting intraoperative and postoperative complications were not evaluated. Thirdly, the scoring of the models was conducted by a single surgeon, and inter-rater concordance was not assessed. The strength of our study is that it is a high-volume study evaluating the effectiveness of the 3 most used models.

CONCLUSION

Guy's score, S.T.O.N.E. score and the CROES nomogram are effective in predicting stone-free status in PNL. To determine which model is more useful and effective, large-volume prospective studies comparing these models in terms of stone-free status and complications are needed.

Conflict of Interest: The authors declare to have no conflicts of interest.

Financial Disclosure: The authors declared that this study has received no financial support.

Ethics Committe: Bakirkoy Dr. Sadi Konuk Education and Research Hospital Clinical Trials Ethics Committee Date Protocol: 02.09.2019/2019-17-22.

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