Medical Scope Journal 2025;7(2):305-309
DOI: https://doi.org/10.35790/msj.v7i2.61296
URL Homepage: https://ejournal.unsrat.ac.id/index.php/msj

Validation of Guy's Stone Score, RUSS, S-RESC SCORE, and S.T.O.N.E Score for Predicting Stone Free Rate in Percutaneous Nephrolithotomy in a Residency Teaching Hospital

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Received: December 23, 2024; Accepted: April 3, 2025; Published online: April 11, 2025

Abstract: Kidney stones represent a significant health burden globally, with a high risk of recurrence. Percutaneous nephrolithotomy (PCNL) is the primary treatment option for kidney stones larger than 20 mm, offering superior outcomes compared to open surgery. Several scoring systems, including Guy's Stone Score (GSS), S.T.O.N.E. Nephrolithometry Score, Resorlu Unsal Stone Score (RUSS), and Seoul Renal Stone Complexity (S-ReSC), have been developed to predict the Stone-Free Rate (SFR) following PCNL. However, the comparative effectiveness of these scoring systems remains unclear. This study aimed to evaluate and compare the predictive accuracy of GSS, S.T.O.N.E., RUSS, and S-ReSC scoring systems in determining SFR after PCNL. This was an analytical and retrospective study. Data were collected from 60 patients with kidney stones treated at Prof. Dr. R. D. Kandou Hospital Manado from January to December 2023. Patients underwent PCNL, and preoperative non-contrast CT scans and postoperative plain abdominal X-rays were used for evaluation. Statistical analyses included univariate, bivariate, and multivariate tests, as well as ROC curve analysis. The results showed that all four scoring systems were statistically significant in predicting SFR ($p<0.005$). The RUSS score demonstrated the highest predictive value, with an odds ratio 20 times higher than without scoring. The ROC analysis showed AUC values of 0.792 for GSS, 0.913 for RUSS, 0.694 for S-ReSC, and 0.945 for S.T.O.N.E. These findings highlight significant relationships between stone complexity scores and SFR, emphasizing their utility in surgical planning. In conclusion, each scoring system has significant predictive value for SFR following PCNL. Among them, RUSS showed the highest reliability, followed by S.T.O.N.E. and GSS. Despite differences in focus, all scores contribute to treatment planning and patient management. Further research is needed to optimize these tools and integrate them with advanced imaging and minimally invasive techniques for personalized patient care.
Keywords: percutaneous nephrolithotomy; kidney stones; Stone-Free Rate; Guy's Stone Score; S.T.O.N.E Nephrolithometry Score; Resorlu Unsal Stone Score; Seoul Renal Stone Complexity

INTRODUCTION

Kidney stone is a common condition in urology and represents a significant health burden today. According to the Indonesian Urological Association, approximately 5-10% of the population is at risk of developing kidney stones, with a high recurrence rate. In Indonesia, kidney stone management has evolved through various minimally invasive techniques, such as percutaneous nephrolithotomy (PCNL), aimed at reducing stone burden and recurrence rates. The PCNL is the best treatment for large and complex upper urinary tract stones. Preoperative imaging is crucial, to establish the diagnosis and to determine the optimal treatment and surgical planning.[1] To date, PCNL is the most recent gold standard treatment for large kidney stones, including staghorn calculi. Although it is a minimally invasive procedure, PCNL carries certain risks and does not always ensure complete stone removal in patients. There are various guidelines for determining the indications for PCNL and the modified Clavien system to assess complications. However, no standardized method exists to predict the Stone-Free Rate (SFR) or clearance after undergoing PCNL.[2,3]

Several scoring systems have been developed for managing PCNL to reduce surgical side effects, assist in patient counseling, and provide standardized assessments of stone complexity. However, to date, none of these scoring systems have been thoroughly studied to determine which is the most reliable predictor of stone-free rates.The Guy's Stone Score (GSS), S.T.O.N.E. Nephrolithometry Score, Resorlu Unsal Stone Score (RUSS), and Seoul Renal Stone Complexity (S-ReSC) score all demonstrate similar effectiveness in predicting SFR.[2] The variation in SFR evaluation results stems from the use of different scoring systems across hospitals. The complexity of kidney stone disease, whose underlying cause is still not clearly understood, often leads to uncertainty regarding patient outcomes following surgery. As kidney stones increasingly contribute to the international health burden each year, there is a need for standardized scoring systems that can serve as valid predictors of SFR. This would provide clear information for patients and their families while improving the effectiveness and efficiency of doctors and healthcare professionals in the management process.[3]

In research related to predicting the success of PCNL, the use of scoring systems is crucial to assess the complexity of kidney stones and predict the likelihood of surgical success. However, there is a gap in understanding the individual and collective effectiveness of these scoring systems in predicting PCNL outcomes. This gap arises from variations in study methodologies, heterogeneous patient populations, and differences in the definitions of success used by researchers.[4]

Additionally, other factors, such as surgical techniques, operator experience, and the technology used, also contribute to this gap. Although previous studies have explored the effectiveness of these predictive scores, there remains a need for more comprehensive data integration and comparative analysis to deeply understand the strengths and limitations of each score in diverse contexts.[5] This calls for further research to bridge this knowledge gap, with the ultimate goal of improving PCNL outcomes for kidney stone patients.[6] Therefore, this study aims to describe the GSS, RUSS, S-ReSC, and S.T.O.N.E. Nephrolithometry Score as predictors of SFR in kidney stone patients undergoing PCNL at Prof. Dr. R. D. Kandou Hospital.

METHODS

Data were collected retrospectively from 60 patients with kidney stones treated at Prof. Dr. R. D. Kandou Hospital, Manado, from January to December 2023. Patients underwent PCNL, and preoperative non-contrast CT scans and postoperative plain abdominal X-rays were used for evaluation. Statistical analyses included univariate, bivariate, and multivariate tests, as well as ROC curve analysis.. Average patient age around 50 years, with a variation of approximately 14 years. Prior to PCNL procedure, the median stone size was about 3.4 cm, with a central distribution between 2.5 cm and 4.3 cm. Calculation of GSS, RUSS, S-RESC Score, and S.T.O.N.E Score for each patient was performed using available data.

RESULTS

The GSS assesment showed that most patients were categorized in grade 2 and 3 (78%). In the RUSS scale, nearly half of the patients received a total score of 1, while the remainder had scores of 2 (28%) or 3 (78%). The median S-ReSC score was 3 (IQR 3-4), and the stone score was 9 (IQR 8-9). The proportion of patients who were stone-free at the end of the percutaneous nephrolithotomy procedure reached 73%. The distribution of GSS, RUSS, STONE, and S-ReSC scores after PCNL indicates a significant relationship between each score and the SFR. A higher proportion of positive SFR tends to be associated with lower GSS grades and RUSS scores. Similar patterns were observed in the STONE and S-ReSC score distributions. The predictive ability based on the area under the ROC curve (AUC) for the 60 study samples was ranked as follows: 1) RUSS; 2) GSS; 3) S-ReSC; and 4) STONE. The DeLong test for AUC differences between the four scoring systems showed no significant differences except between GSS and RUSS (p=0.045).

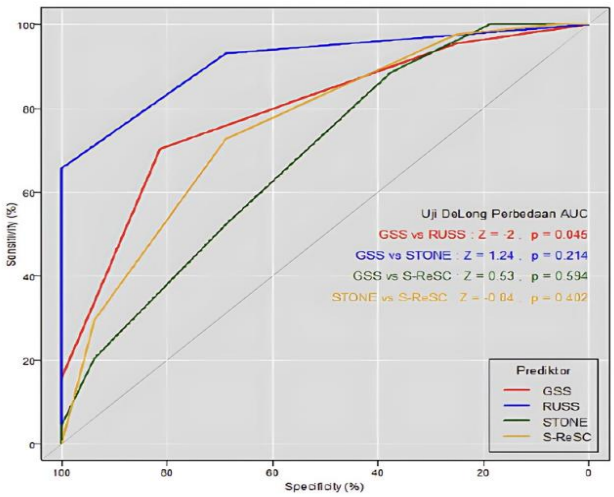

Figure 1. ROC curve for the predictive ability of GSS, RUSS, STONE, and S-ReSC in predicting stone-free rate

Table 1. Description of Research Variables, N = 60

Characteristics	N (%)	Med (Q1;Q3) Mean ± SD	Sensivity	Specivity	Accuracy
Man	27 (45%)	-			
Woman	33 (55%)	-			
Age	-	50.2 ± 13.7			
Stone Size (cm)	-	3.4 (2.5;4.3)			
GSS			71%	81%	73%
1	7 (12%)	-			
2	27 (45%)	-			
3	20 (33%)	-			
4	6 (10%)	-			
RUSS			66%	100%	75%
1	29 (48%)	-			
2	17 (28%)	-			
3	14 (23%)	-			
S-ReSC	-	3.0 (3.0;4.0)	73%	69%	72%
S.T.O.N.E	-	9.0 (8.0;9.0)	89%	38%	65%
SFR					
Negatif	16 (27%)				
Positif	44 (73%)				

The GSS demonstrates a good balance between sensitivity and specificity, with a high accuracy of 73%, and most patients falling into GSS-2 (45%) and GSS-3 (33%). The RUSS stands out with high specificity (100%) and good accuracy (75%), making it a reliable predictor, with the majority of patients classified under RUSS-1 (48%). The S-ReSC has a median score of 3.0, showing fairly balanced sensitivity and specificity, with moderate accuracy (72%). In contrast, the S.T.O.N.E. Score demonstrates high sensitivity (89%) but very low specificity (38%), resulting in the lowest accuracy among the scoring systems (65%). Overall, the SFR shows that most patients (73%) achieved a stone-free status after the procedure, indicating the overall success of PCNL.

DISCUSSION

According to the guidelines for kidney stone management issued by the Indonesian Urological Association, PCNL is the primary choice for managing kidney stones larger than >20 mm.[1] This procedure has proven to be more effective in achieving SFR compared to open surgery. Preoperative imaging plays a key role, not only in confirming the diagnosis but also in determining the most suitable treatment and surgical approach. Non-contrast CT scan (CTKUB) is the gold standard imaging technique for urolithiasis, as it can assess stone complexity, including size, density, and distribution within the collecting system, as well as the anatomy of the pelvi-calyceal system and the orientation and anatomical relationship of the kidneys. Several scoring systems have been developed to predict the likelihood of achieving SFR after PCNL.[7] The most validated and commonly used clinical scoring systems include GSS, S.T.O.N.E. Nephrolithometry Score, RUSS, and S-ReSC. This study aims to compare these scoring systems in predicting SFR through evaluations using non-contrast CT scans and plain abdominal X-rays (BNO) post-PCNL.[8]

In this study, based on univariate and bivariate analyses, each scoring system significantly predicts the SFR. This is supported by chi-square tests, where all scoring systems showed significant results ($p<0.005$). In multivariate analysis, the p-values for each scoring system were >0.005, requiring the removal of scoring systems with the highest p-values. After further testing, Odds Ratio values of >10% indicated that the S.T.O.N.E. score acted as a confounding variable. Multivariate analysis revealed that the RUSS score was 20 times more significant in predicting SFR compared to not using any scoring system.

Direct comparisons between these scoring systems in the literature have provided diverse insights. Some studies highlight the superiority of one score over another, while others find that all scores have similar predictive values. Findings from our study indicate that each scoring system, despite having slightly different focuses of evaluation, is significantly associated with the likelihood of achieving SFR after PCNL. This suggests that the choice of which score to use may depend on individual preference and clinical context.[7] Each system has advantages and disadvantages, but several studies suggest that their ability to predict stone-free rate is comparable. The optimal system should have a high predictive ability, should be simple to use and should be widely applicable.[9]

The statistical significance of the relationship between kidney stone complexity scores and SFR emphasizes the importance of these factors in treatment planning and patient management. It underscores the need for an integrated approach that considers various aspects of stone complexity in making therapeutic decisions, especially in complex treatments like PCNL.[10]

It is clear from our study and other reported works that all of these scoring systems were effective in predicting stone-free status, length of stay, and operating time. Since both systems accurately predicted these outcomes, they can serve as useful "stratification tools," helping both the surgeon and the patient understand the complexity of each procedure by providing an indication of whether the case is likely to be "easy" or "difficult." When interpreting these findings, it is also important to acknowledge the limitations of kidney stone complexity scores. While these scores provide a framework for risk evaluation and expectation setting, they cannot

replace comprehensive clinical assessments that consider all aspects of the patient's condition and preferences. Integrating quantitative findings, as provided by the complexity scores, with qualitative evaluations of clinical and patient factors will optimize treatment strategies.

Furthermore, this study highlights the need for future research to explore how these scores can be combined or used alongside new technologies, such as advanced imaging and minimally invasive surgical techniques, to improve outcome prediction accuracy and personalize patient care. Additional studies are required to evaluate patient clinical factors that influence stone complexity and are predictive of outcomes. The significance of this study lies in confirming that comprehensive preoperative evaluations, including the use of kidney stone complexity scores, are crucial in predicting PCNL success. These findings also provide important guidance for practitioners in optimizing approaches to kidney stone management, with the potential to improve patient outcomes and reduce the need for additional interventions.

Ultimately, the findings of this study strengthen the argument for further development and validation of predictive tools in urology, with the aim of expanding our understanding of the factors influencing kidney stone treatment success. Through this research, it is expected that the quality and effectiveness of care provided to kidney stone patients can be enhanced and directed towards more personalized strategies, resulting in better outcomes.

CONCLUSION

The Guy's Stone Score system, the S.T.O.N.E. Nephrolithometry Score system, the Resorlu Unsal Stone Score (RUSS) system, and the Seoul National University Renal Stone Complexity Score (S-ReSC) system are statistically significant as predictors of Stone-Free Rate after percutaneous nephrolithotomy.

Conflict of Interest

The authors effirm no conflict of interest in this study.

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