Medical Scope Journal 2025;7(1):167-174
DOI: https://doi.org/10.35790/msj.v7i1.57388
URL Homepage: https://ejournal.unsrat.ac.id/index.php/msj

Comparison of Scoring Systems in Predicting Stone-Free Rate in Flourless Retrograde Intrarenal Surgery

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Received: August 8, 2024; Accepted: September 13, 2024; Published online: September 15, 2024

Abstract: Thus far, there is no standardised method for predicting outcomes from fluoro-less retrograde intrarenal surgery (RIRS) procedure. This study aimed to compare scoring systems in predicting stone-free rate (SFR) in RIRS patients This was an observational and analytical study with a retrospective cohort design. Samples were obtained from medical records of Dr. J. H. Awaloei Hospital from March 2022 to October 2023. This study only analyzed three scoring systems: Guy's Stone Score (GSS), Resorlu-Unsal Stone Score (RUSS), and Seoul National University Renal Stone Complexity Score (S-ReSC). The results obtained 219 patients with an average age of 55 years, GSS grade I in 108 patients, and grade II in 50 patients. Related to RUSS score, 43 patients got a score of 1, 108 got a score of 2, and 60 got a score of 60. Meanwhile, S-ReSC score was at a high level with a percentage of 65.3%, 20.4% at the medium level, and 14.4% at the low level. Moreover, GSS sensitivity 76%, specificity 75%, PPV 93.2%, NPV 41.1%, AUC 75%; RUSS score sensitivity 75.4%, specificity 62.2%, PPV 90%, NPV 36.2%, AUC 70%; S-ReSC score sensitivity 71%, specificity 77.5%, PPV 93.4%, NPV 37.3%, AUC 72%. In conclusion, Guy's Stone Score, Resorlu-Unsal Stone Score, and Seoul National University Renal Stone Complexity Score have similar abilities in predicting stone-free rate. Further research is needed with a larger sample size or population to confirm the findings of this study.
Keywords: nephrolithiasis; stone-free rate; scoring system; retrograde intrarenal surgery

INTRODUCTION

Nephrolithiasis, often known as kidney stones, is a kidney disorder characterized by the presence of stones composed of crystal components and organic matrix. It is the leading cause of urinary tract abnormalities. Kidney stones are commonly located in the calyx or pelvis. When the stones pass through, they might obstruct the ureter (ureteral stones) or the bladder (bladder stones).[1] Kidney stones can develop as a result of calcium, oxalate stones, calcium oxalate, or calcium phosphate. Calcium stones are the most prevalent type of kidney stones. The precise etiology of kidney stones remains elusive due to the involvement of numerous variables. Kidney stones are believed to be caused by two processes: supersaturation and nucleation.[2] Supersaturation happens when there is a high concentration of the compounds that form stones in the urine. This occurs when the volume of urine drops and the urine chemistry that prevents stone formation is reduced. The process of nucleation involves the formation of nuclei consisting of sodium hydrogen urate, uric acid, and hydroxyapatite crystals. Calcium and oxalate ions adhere to each other in the core, resulting in the formation of a combination of stones. The term used to describe this phenomenon is heterogeneous nucleation.[3]

In the last three decades, the prevalence of kidney stones has increased. The incidences of nephrolithiasis between developed and developing countries are different because nephrolithiasis in developed countries is generally without symptoms. Increased consumption of salt and protein, as well as increased prevalence of metabolic syndrome, are associated with a high prevalence of nephrolithiasis in developed countries. At the same time, malnutrition and limited water sources contribute to an increase in the prevalence of nephrolithiasis in developing countries.[4,5] The National Health and Nutrition Examination Survey (NHANES) reports an increase of 10.1%. Meanwhile, based on age, the incidence of nephrolithiasis increased to 9.3%.[5] Liu et al[6] reported that in West Asia, Southeast Asia, South Asia, South Korea, and Japan, the incidence of nephrolithiasis was 5–19.1%. The prevalence and incidence of nephrolithiasis have increased in most parts of Asia in the last few decades.[7] The incidence of nephrolithiasis in Indonesia reached 1,499,400, experienced mainly by people aged 30-60 years, 10% in women and 15% in men. The prevalence of experiencing kidney stones throughout life is estimated to vary between 1-15%, with three times as many men suffering as women.[8]

In general, the formation of kidney stones is affected by intrinsic and extrinsic factors. Intrinsic factors are age, gender, and heredity, while extrinsic factors are geographical conditions, climate, eating habits, substances contained in urine, and so on. In confirming the diagnosis of nephrolithiasis, CT examination of the abdomen and pelvis without contrast is the gold standard for radiological examination of kidney stones. Meanwhile, a urinalysis is performed to look for hematuria, crystals, and signs of infection. In patients with kidney stones, laboratory tests must also be carried out to assess kidney function, serum calcium, phosphate, and uric acid. This examination is recommended to identify accompanying metabolic disorders.[9]

Operative treatment for kidney stones is usually carried out for stones measuring more than 0.5 cm.[10] One of the operative treatment options for kidney stone surgery is retrograde intrarenal surgery (RIRS). This RIRS has been carried out widely in the last few decades, along with developments in technology and science. Improving the quality of flexible ureteroscopes, instruments, and operator experience is essential in using RIRS as a treatment option for kidney stone patients. Previous studies reported that the RIRS stone-free rate (SFR) was higher than Extracorporeal Shock Wave Lithotripsy (ESWL).[11] Recent studies reported that the stone-free rate in the retrograde ureteroscopic treatment of kidney stones was >90%, while in the treatment of lower pole (pole) stones reached 85%. In addition, several research groups have proven the success of RIRS surgery in treating large kidney stones.[12]

In addition to RIRS, other minimally invasive surgical techniques have been developed, such as percutaneous nephrolithotomy (PNCL), which is now considered as the most effective and preferred treatment for large kidney stones. This PNLC, a complicated procedure, is recommended by the European Association of Urology and the American Urological Association. Multiple studies indicate that PCNL has a superior rate of stone clearance and a reduced likelihood of requiring additional surgical procedures. Nevertheless, there are still concerns over the efficacy and potential complications of the treatment, including the need for blood transfusion due to bleeding, the risk of urosepsis, and the possibility of acute renal impairment requiring intensive care. Developing a scoring system that can properly predict the success rate of intervention for kidney stones, including the SFR and associated problems, offers significant advantages for both clinicians and patients.[13]

Various grading systems and nomograms have been created using these parameters to forecast the effectiveness of therapies in treating kidney stones. Several scoring systems that can be used include Guy's Stone Score (GSS), Resorlu-Unsal Stone Score (RUSS), Seoul National University Renal Stone Complexity Score (S-ReSC), RIRS, and STONE. The GSS is a straightforward, valid, and reliable approach for assessing the state of stones and estimating the likelihood of being free from stones.[12] The RUSS is also a straightforward scoring system that can accurately predict the likelihood of being free of stones after undergoing retrograde intrarenal surgery (RIRS). RUSS has undergone external validation, demonstrating substantial accuracy in its predictions. The RIRS grading system utilizes CT urography to obtain all its components, enabling the prediction of the characteristics of stones observed in the reproductive system. The density of renal calculi is described by an attenuation coefficient ranging from 1 to 2 points, determined by values equal to or less than 1000 Hu, or greater than 1000 Hu. The STONE Score is a scoring system that aims to predict a patient's SFR based on preoperative characteristics obtained from Computed tomography of kidneys, ureters and bladder (CT-KUB). These characteristics include stone size (S), topography or location (T), degree of obstruction or blockage in the urinary tract system (O), number or source of stones (N), and evaluation or assessment of Hounsfield units (E). The assessment of renal stone complexity at Seoul National University starts with analyzing the results of PCNL in terms of stone distribution, rather than stone number or size. This approach allows the system to anticipate the success rate of stone fragmentation and removal after PCNL.[13]

There is no standardised method for predicting outcomes from RIRS interventions given to patients, therefore, in this study, we compared five scoring systems, namely: Guy's Stone Score, Resorlu-Unsal Stone Score, Seoul National University Renal Stone Complexity Score (S -ReSC), RIRS, and STONE to compare SFR in post-RIRS patients.

METHODS

This was an observational and analytical study with a cohort retrospective design, namely research that follows the patient's progress over a certain period without intervention. This study compares scoring systems in predicting SFR in RIRS patients. This study design was chosen due to the availability of suitable retrospective cohort data for analytical purposes. This approach is considered more time- and resource-efficient than the alternative, namely, prospective cohort studies, and it still allows for good quality data for analysis.

The research population was patients who underwent RIRS surgery at Dr. J. H. Awaloei Hospital, recorded in the medical records from March 2022 to October 2023. The sampling technique employed in this study was a probability sampling strategy. This probability sampling ensures that every element in the population has an equal chance of being picked as a sample member. Moreover, this methodology enables researchers or evaluators to extrapolate population characteristics from a representative sample. The study's inclusion criteria were as follows: 1) participants had to be over 18 years old; 2) their medical records had to include incomplete examination results data; 3) diagnosed with kidney stones using a non-contrast urological CT scan and underwent RIRS; and 4) be willing to participate as research subjects. Furthermore, the exclusion criteria encompass patients with stones larger than 2 cm and those with congenital or structural anomalies of the urinary system.

An examination of the description of each variable was conducted based on the distribution type. Categorical variables are represented by their frequencies and percentages. The diagnostic test results were presented in a 2x2 table, from which the sensitivity, specificity, accuracy, and positive and negative predictive values were derived. The predictive capacity of GSS, RUSS, S-ReSC, RIRS, and STONE in determining the stone free rate was assessed using receiver operating characteristics (ROC) curve analysis. The outcomes were presented as sensitivity values, specificity, and accuracy, based on the optimal threshold determined by the J Youden index. The area under the curve (AUC) was quantified by the c statistic and was accompanied by a 95% confidence interval. The AUC evaluated the performance of the test and encompassed the entirety of the area beneath the curve that was generated by plotting all the sensitivity and 1-specificity coordinates. The AUC number varied between 0 and 1. A higher AUC indicates a greater ability of a test to accurately identify a condition.

RESULTS

Subjects involved in this study included 216 patients whose data were collected during the study. Table 1 showed the characteristics of subjects. Generally, men have a proportion of 3:1 compared to female patients. The average age of the subjects was 55 years, with a variation of almost 13 years. The actions used in these patients were right RIRS, left RIRS, and bilateral RIRS. Regarding the GSS score assessment results, 108 patients (50%) were in grade I, while 50 patients (50%) were in grade II.

Tabel 2 showed the sensitivity and specificity analysis of GSS, S-ReSC, and RUSS. Overall, the GSS score showed higher accuracy than the S-ReSC and RUSS scores. The GSS prediction results showed sensitivity and specificity of 76% and 75%, respectively, with PPV 93.2% and NPV 41.1%. Indeed, these results must be considered carefully, considering that the analysis was carried out on a limited population and the number of patients who later experienced a SFR cannot theoretically provide stable statistics. Meanwhile, the distribution of the RUSS score was only limited to values 1-3, with the distribution not being too even, so the sensitivity of the SFR prediction

Table 1. Characteristics of patients

Characteristics of patients	n	%	Mean ± SD
Gender			
Male	167	76.3	
Female	52	23.7	
Age			57.3 ± 10.9
Procedure			
Right RIRS	96	43.8	
Left RIRS	98	44.7	
RIRS Bilateral	3	1.36	
Others	22	10.04	
Scoring			
GSS			
I	108	49.3	
II	111	50.7	
SReSC			
Low	31	14.2	
Medium	46	21.0	
High	142	64.8	
RUSS			
1	43	19.6	
2	110	50.2	
3	61	27.9	
Stone Free Rate			
Yes	179	82.1	
No	39	17.9	

was recorded at 75.4%, specificity 62.2%, PPV 90%, NPV 36.2%. This value may still change in the same study with different sample conditions. In others, the S-ReSC score appeared to have a sensitivity of 71%, with specificity reaching 77.5% with a PPV value of 93.4% and NPV of 37.3%.

Table 2. Sensitivity and specificity analysis

Scoring	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
GSS	76	75	93.2	41.1
S-ReSC	71	77.5	93.4	37..3
RUSS	75.4	62.5	90	36.2

PPV, positive predictive value; NPV, negative predictive value

Figure 1-3 showed the distribution of S-ReSC scores tended to be centred at the high level with a percentage of 65.3%, 20.4% at the medium level, and 14.4% at the low level. On the RUSS score, 43 patients had a score of 1, 108 patients had a score of 2, and 60 patients had a score of 60.

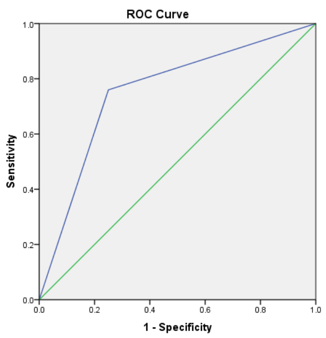

Figure 1. ROC curve GSS

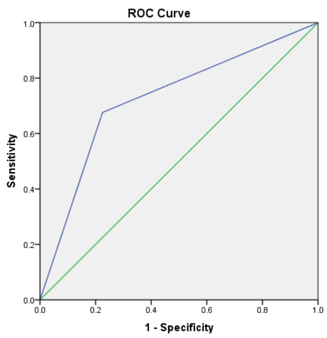

Figure 2. ROC curve S-ReSC

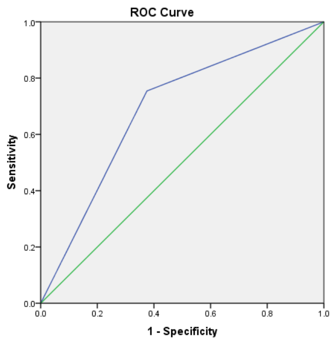

Figure 3. ROC curve RUSS

In this study, further analysis was carried out on three scoring systems: GSS, S-ReSC, and RUSS. Moreover, this study did not use the RIRS and STONE scoring systems. Tabel 3 showed the AUC values of the three scoring systems. The ability of GSS to predict the freestone rate is good, with an AUC of 0.75 (75%) or ≥ 70%. Similar to GSS scoring, in the RUSS scoring system, an AUC value of 0.70 (70%) or ≥ 70% is obtained, indicating that this scoring can predict the stone-free rate. Another scoring system, S-ReSC, obtained an AUC of 0.72 (72%) or ≥ 70%, indicating that this scoring is good in predicting the stone-free rate.

Table 3. AUC values of the scoring systems

Scoring	AUC	95% CI
GSS	0.75	0.66 – 0.84
S-ReSC	0.72	0.64 – 0.81
RUSS	0.70	0.59 – 0.78

DISCUSSION

Several scoring systems and nomograms have been developed with these factors to predict the success of interventions in the management of kidney stones, such as Guy's Stone Score (GSS), Resorlu-Unsal Stone Score (RUSS), Seoul National University Renal Stone Complexity Score (S-ReSC), retrograde intrarenal surgery (RIRS), and STONE. In this study, we compared three scoring systems, namely GSS, S-ReSC, and RUSS to predict stone-free rates in post-RIRS patients.

In this study, there were 216 patients who had received RIRS procedures in the form of right RIRS, left RIRS, and bilateral RIRS. The SFR in this study reached 82.1% compared to the incidence of no SFR, which reached 17.9%. This study found that the GSS showed a higher level of accuracy than the S-ReSC and RUSS, with a value of 58%. These results must be considered carefully, considering that the analysis was carried out on a limited population and the number of patients who later experienced a stone-free rate could not theoretically provide stable statistics.

Sensitivity shows the ability of an examination to test positively for a sick person. The higher the sensitivity of an examination, the more positive examination results will be obtained in people who are sick or the fewer the number of false negatives.[14-17] Specificity shows the ability of an examination to declare negative in people who are not sick.[18] The higher the specificity of an examination, the more results negative tests in people who are not sick or the number of false positives is reduced.[19-20] This study found that GSS, S-ReSC, and RUSS scoring had similar abilities in predicting the SFR. The GSS prediction results showed sensitivity and specificity of 76% and 75%, respectively, with PPV 93.2% and NPV 41.1%. The RUSS score is only limited to values 1-3 with a distribution that is not very even, so the sensitivity of SFR prediction is recorded at 75.4%a, specificity 62.2% with PPV 90%, NPV 36.2%. While the S-ReSC score appeared to have a sensitivity of 71%, the specificity reached 77.5% with a PPV value of 93.4% and NPV of 37.3%. This research also found that the ability of GSS to predict the freestone rate was reasonable, with an AUC of 0.75 (75%) or ≥ 0%. Similar to GSS scoring, in the RUSS scoring system, an AUC value of 0.70 (70%) or ≥0% was obtained, indicating that this scoring could predict the SFR. Other scoring systems, such as the S-ReSC scoring system, obtained an AUC of 0.72 (72%) or ≥70%, indicating that this scoring was suitable for predicting the SFR.

In recent years, predicting the stone-free rate and risk of complications before surgery has become quite interesting in endourology. Several nomograms have been developed to predict postoperative success rates: ESWL, ureteroscopy (URS), PCNL, and RIRS.[21] The GSS is a simple and reliable tool for predicting success rates considering the location of the stone and kidney anatomy.[22] A higher score indicates a higher stone-free rate. Low. The stone-free rate also does not depend on stone burden, surgeon experience, age, body weight, and patient comorbidities.[23] In a PCNL study, the SFR reached between 0 and 100% for GSS.[24] In that study, the incidence of residual stones was higher in patients with GSS Grade 2.[25] One study showed that ROC curve analysis revealed S-ReSC as the least sensitive scoring system in predicting stone-free status, compared with other nomograms.[26] Another study with PCNL reported an overall stone-free rate of 59% (92/157) with a complication rate of 22% (35/157).[27] A stone burden of 542 mm^3 was shown to have a significant association with the SFR (p=0.001). Univariate analysis indicated that all rating systems were significant contributors in SFR. The scores of GSS, CROES, and S-ReSC were significantly correlated with the occurrence of complications ($p<0.02$). A multivariate logistic regression analysis of the study revealed that the CROES score was shown to be a significant predictor in both SFR and complications ($p<0.01$).[28] The receiver operating characteristic curve (ROC) analysis demonstrated encouraging findings for stone burden, GSS, STONE score, CROES score, and S-ReSC score, with respective area values of 0.737, 0.674, 0.762, 0.746, and 0.710. Additionally, 30 other studies have shown that the frequencies of initial stone and complication-free outcomes after PCNL were 78.7% (111 out of 141 cases) and 17.0% (24 out of 141 cases), respectively.

In a prior study, univariate analysis revealed that all three scoring systems were found to be significant determinants in relation to the SFR.[29] The multivariate logistic regression analysis of the study revealed that there was a significant link between the GSS and stone load ≥385 mm2 and the stone-free status. The odds ratio for the GSS was 3.220 with a p-value of 0.001, while the odds ratio for the stone burden ≥385 mm2 was 6.451 with a p-value of 0.002. The stone score of the individual (OR=1.879, p 0.013) was identified as a separate risk factor for the development of problems.[30] The ROC curves for GSS, STONE, and CROES, as well as stone burden, showed good results with respective AUC values of 0.821, 0.816, 0.820, and 0.800.[30] The pairwise assessment of the ROC curves in this study revealed no statistically significant difference between any final score and stone burden. These results confirmed our previous findings that GSS demonstrated a high level of accuracy in predicting stone-free rates.[31]

CONCLUSION

The Guy's Stone Score (GSS), Resorlu-Unsal Stone Score (RUSS), and Seoul National University Renal Stone Complexity Score (S-ReSC) demonstrate comparable predictive powers in determining the stone-free rate, with sensitivity values of 76%, 71%, and 75.4%, respectively. Furthermore, the area under the curve (AUC) values for each scoring method demonstrate a strong predictive ability for the stone-free rate. Specifically, the AUC values for GSS, S-ReSC, and RUSS are all ≥70%, with values of 75%, 72%, and 70%, respectively.

Conflict of Interest

The authors affirm no conflict of interest in this study.

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