Original Article

Effectivity of Percutaneous Nephrolithotomy versus Retrograde Intrarenal Surgery on Kidney Stone: A Single-center Experience

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Abstract

Introduction: Urinary tract stones are one of the most prevalent urological diseases worldwide. Percutaneous nephrolithotomy (PCNL) and retrograde intrarenal surgery (RIRS) are two primary treatment modalities for the said disease. This study analyzes and compares the clinical characteristics and outcomes of kidney stone patients undergoing PCNL and RIRS in Indonesia. **Methods:** We retrospectively analyzed patients with urinary tract stones who underwent PCNL and RIRS in a single hospital. Patient characteristics were retrieved from medical records between January 2022 and December 2023. We compared the age, gender, number, size of stones, as well as preoperative imaging, comorbid diseases, and stone-free rate (SFR) of the patients. **Results:** From January 2022 to December 2023, 116 cases of kidney stones were found in Universitas Airlangga Hospital. Sixteen patients underwent the RIRS procedure, and 100 patients underwent the PCNL procedure. **Conclusions:** Patients who underwent PCNL procedures for kidney stones are generally men over 40 years old with kidney stones larger than 2 cm and < 2 cm for RIRS procedures. The PCNL procedure has an overall higher SFR than the RIRS procedure, especially for large and complex stones. However, RIRS has a higher success rate for stones under 2 cm. The SFR of both modalities decreases as the Guy's stone score increases.

Keywords: *Health risks, life expectancy, nephrolithiasis, percutaneous nephrolithotomy, retrograde intrarenal surgery*

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Introduction

Urinary tract stones are a major problem worldwide. In several countries around the world, it ranges from 1% to 20%, with men occurring more frequently than women, where the peak incidence occurs at the age of 40–50 years.[1] However, Indonesian data remained inconclusive as limited studies on this disease are available.

The prevalence of urinary tract stones, especially kidney stones, differs between developed and developing countries, where the detection of symptomless kidney stones is more common in developing countries. Increased consumption of salt and protein, as well as the ascending prevalence of metabolic syndrome, has been associated with a higher prevalence of kidney stones in developed countries. In contradiction, malnutrition and lack of water can contribute to the increasing prevalence of kidney stones in developing countries.[2]

Active removal of kidney stones is recommended in stones measuring >15 mm, stones that induce symptoms such as hematuria or pain, urinary tract infections, increased stone size, urinary tract obstruction caused by stones, and decreased kidney function. Percutaneous nephrolithotomy (PCNL) and retrograde intrarenal

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surgery (RIRS) are the two primary treatment modalities for kidney stones. PCNL is the most preferred modality for complex kidney stones and large stones (>2 cm), whereas RIRS is considered an effective treatment for smaller kidney and ureter stones measuring <2 cm.[1,3,4]

There is currently limited data on the incidence of kidney stones in patients over the last 2 years, particularly at Universitas Airlangga Hospital in Surabaya, Indonesia, a major tertiary referral center in Indonesia. To determine the most appropriate treatment modality, the author considers it necessary to perform a study comparing the two readily available modalities in the said hospital to ensure excellent patient care.

Methods

We performed a retrospective cohort analysis conducted at Universitas Airlangga Hospital, Surabaya, utilizing medical record data from January 2022 to December 2023. The study protocol received ethical clearance from the Health Research Ethics Committee of Universitas Airlangga Hospital (reference number UA-02-24025). The primary objective of this research was to evaluate the clinical and demographic characteristics of patients diagnosed with nephrolithiasis who underwent either PCNL or RIRS. The retrospective design enabled the analysis of a well-defined patient cohort, relying on comprehensive historical data.

The study population consisted of male patients aged 18 years and above, diagnosed with nephrolithiasis, and treated with either PCNL or RIRS. Inclusion criteria required patients to be male, 18 years of age or older, with a confirmed diagnosis of nephrolithiasis, and to have undergone one of the specified surgical interventions. To ensure data quality, only patients with complete and accurate medical records were included in the study. Exclusion criteria encompassed patients under 18 years of age, those who had undergone alternative surgical interventions for stone removal, and individuals with incomplete or missing data.

Key variables collected for analysis included patient demographics (age and gender), stone characteristics (number, size, and location), preoperative imaging findings, comorbidities, and the stone-free rate (SFR) following surgery. The SFR was assessed using Guy's stone score to categorize the complexity and likelihood of achieving a stone-free status postoperatively. These data points were extracted from the hospital's electronic medical record system. Data analysis was primarily descriptive and is summarized in the form of percentages. This approach allowed for detailed interpretation of patient demographics, surgical outcomes, and the effectiveness of PCNL and RIRS in achieving postoperative stone-free status. Age, stone type, stone size, preoperative imaging, gender, comorbidities, and SFR were assessed for both PCNL and RIRS patients, with all data presented as frequencies and percentages.

Results

From January 2022 to December 2023, we identified 116 kidney stone cases. They were then categorized by patient characteristics such as age and gender, treatment types (RIRS and PCNL), number and size of stones, preoperative imaging, comorbidities, and SFR. Patient characteristics are presented in Table 1.

Table 1: Characteristics of kidney stone patients

Variable	RIRS, *n* (%)	PCNL, *n* (%)
Gender		
Male	11 (68.8)	57 (57)
Female	5 (31.2)	43 (43)
Total	16 (100)	100 (100)
Age		
18–20	0	1 (1)
21–30	0	7 (7)
31–40	0	10 (10)
41–50	3 (18.8)	28 (28)
51–60	8 (50)	28 (28)
>60	5 (31.2)	26 (26)
Total	16 (100)	100 (100)
Type of stone		
Single	1 (6.25)	26 (26)
Multiple	12 (75)	62 (62)
Staghorn	3 (18.75)	12 (12)
Total	16 (100)	100 (100)
Size of stones (cm)		
<2	9 (56.25)	53 (53)
>2	7 (43.75)	47 (47)
Total	16 (100)	100 (100)
Imaging preoperative		
CT stonography	12 (75)	95 (95)
USG urology	1 (6.25)	1 (1)
BOF	3 (18.75)	4 (4)
Total	16 (100)	100 (100)
Comorbidities		
No comorbidities	6 (37.5)	44 (44)
Diabetes mellitus	0	9 (9)
Hypertension	7 (43.75)	25 (25)
Chronic renal failure	0	0
Tuberculosis	0	0
Hyperlipidemia	0	1 (1)
Diabetes mellitus and hypertension	3 (18.75)	16 (16)
Diabetes mellitus, hypertension, and chronic renal failure	0	3 (3)
Hypertension and tuberculosis	0	2 (2)
Total	16 (100)	100

CT: Computed tomography, USG: Ultrasonograghy, RIRS: Retrograde intrarenal surgery, PCNL: Percutaneous nephrolithotomy, BOF: Buikoverzichtsfoto

SFR for PCNL and RIRS treatments are shown in Tables 2 and 3.

In terms of the gender distribution of patients who underwent RIRS, 11 people were men (68.8%), and 5 other people were women (31.2%). The majority of patients, being eight patients, were at the age range of 51–60 (50%), followed by the age range of over 60 years which includes 5 patients, (31.2%), and finally in the age range 41–50 years as many as 3 (18.8%) people. The total number of kidney stone patients who underwent the RIRS procedure was 16 [Table 1].

There were 100 patients who underwent PCNL, in which 57 were men (57%) and 43 were women (43%). Based on age, the majority of patients were in the age range of 41–50 and 51–60 years, with 28 patients, respectively, (28%). This was followed by individuals over 60 years which included 26 (26%) patients, and finally at the age of 31–40 years, including 10 patients. (10%) [Table 1].

Focusing on the number of stones in the RIRS group, there were 12 patients in the multiple stone group (75%), 1 patient in the single stone group (6.25%), and 3 patients in the staghorn group (18.75%). On the other hand, according to the size of the stones, the majority of patients had stones <2 cm (9 patients, 56.25%) and 7 people had stones sized >2 cm (43.75%) [Table 1].

Data extracted showed that most PCNL (62%) patients had multiple stones. In addition, there were 26 (26%) patients with single stones and 12 (12%) patients with staghorn stones. According to stone sizes, 53% of patients had stones <2 cm and 47% of patients had stones >2 cm [Table 1].

Most patients underwent computed tomography (CT) stenography (75%) before RIRS, followed by 3 patients who underwent BOF (18.75%), and one patient who underwent ultrasonography (6.25%). A similar result was seen in patients who underwent PCNL with the majority of patients undergoing CT stenography (92.2%).

In terms of comorbidities, patients with RIRS were mostly found with a comorbidity of hypertension only (43.75%), and type 2 diabetes mellitus (T2DM) and hypertension (18.75%). The majority of patients with PCNL, on the other hand, also suffered from similar comorbidities being hypertension (25%), T2DM and hypertension (15%), solely T2DM (9%), a combination of T2DM, chronic kidney disease, and hypertension (3%), hypertension and tuberculosis (2%), and solely hyperlipidemia (1%).

The average SFR of patients who underwent PCNL is 70%, whereas the average SFR of patients who underwent RIRS is 56%. Twelve out of 14 patients with Grade 1 Guy's score grading stones achieved an 86% SFR with PCNL, and the only patient with the same grading achieved a 100% SFR with RIRS. In patients with Grade 2 Guy's score grading, 37 out of 48 patients achieved an SFR of 77% with PCNL, and 5 out of 8 patients with the same grade achieved an SFR of 63%. Out of the patients with Grade 3 Guy's score grading, a 65% and 50% SFR were seen with PCNL and RIRS, respectively. Patients with Grade 4 Guy's score grading had a 48% SFR with PCNL and 33% SFR with RIRS, respectively [Tables 2 and 3].

Table 2: Characteristics of stone-free rate in kidney stone patients with retrograde intrarenal surgery procedure

Guy's score	Stone-free status		SFR (%)
	Positive	Negative	
Grade 1	0	1	100
Grade 2	3	5	63
Grade 3	2	2	50
Grade 4	2	1	33
Total	7	9	56

SFR: Stone-free rate

Table 3: Characteristics of stone-free rate in kidney stone patients with percutaneous nephrolithotomy procedure

Guy's score	Stone-free status		SFR (%)
	Positive	Negative	
Grade 1	2	12	86
Grade 2	11	37	77
Grade 3	6	11	65
Grade 4	11	10	48
Total	30	70	70

Discussions

The results of this study highlight a notable gender disparity among kidney stone patients treated with both RIRS and PCNL. Based on the previous results of research regarding kidney stone patients treated with RIRS or PCNL, it was found that the majority were male, comprising 67 patients out of 116 patients. This is in line with many studies that assert a higher prevalence of kidney stones in men in comparison to women.[5-7] In a study conducted in Japan, it was stated that the possibility of having kidney stones was 2.5 times higher in men compared to women, which may be influenced by an array of factors.[8] For instance, hormones, such as testosterone, can play a role in the formation of kidney stones by increasing glycolate oxidase activity and urinary oxalate excretion.[9] However, the Nationwide Inpatient Sample study shows a decrease in the male-to-female ratio in patients discharged from the

hospital with a primary diagnosis of kidney or ureter stones, from 1.7:1 in 1997 to 1.3:1 in 2002.[10] This is associated with an increased prevalence of kidney stones in postmenopausal women.[11] Similar to testosterone, estrogen can reduce the surface expression of two calcium oxalate crystal receptors, reduce the crystal binding ability, and reduce intracellular ATP in renal tubular cells. These three mechanisms create a favorable environment for the formation of kidney stones in the kidneys in men and postmenopausal women, who inevitably have a lower level of circulating estrogen.[12]

The age of patients with kidney stone who underwent the PCNL procedure reveals a concentrated distribution of patients in the middle-aged group, particularly between 41 and 60 years old. This indicates that individuals in this age range are more commonly affected by kidney stones. Previous studies have found that the highest age prevalence of kidney stones undergoing RIRS or PCNL therapy was in the age groups of 41–50 years old and 51–60 years old.[13] A global report study on the prevalence and incidence of kidney stones noted that in countries including Iceland, Iran, Italy, Greece, Turkey, and Germany, the risk of developing kidney stones increases with age. However, in Italy, a sharp decrease of incidents in patients aged above 70 years was seen among residents of Milan.[14] However, the reason behind this increase in productive-aged individuals may be due to jobs that require much energy compared to others as well as insufficient fluid consumption, inappropriate eating patterns, and high levels of work stress, which influences the formation of kidney stones.[15]

The analysis reveals the characteristics of kidney stones in patients managed with RIRS and PCNL procedures, revealing that multiple stones are more common in both groups, complicating treatment. Staghorn stones in the RIRS group indicate a more advanced disease state. Most patients in both groups had stones smaller than 2 cm, suggesting a potentially better prognosis. The reliance on CT stenography for preoperative imaging underscores the importance of accurately assessing stone burden and anatomy, facilitating effective surgical planning. Overall, understanding the number, size, and imaging characteristics of kidney stones is crucial to optimize treatment strategies and improving patient outcomes.

In addition, this study reveals the range of comorbidities among patients undergoing RIRS and PCNL procedures. In the case of RIRS, hypertension emerged as the most common comorbidity, followed by a notable number of patients who had no underlying health conditions, and a smaller group with both diabetes mellitus and hypertension. This suggests that while hypertension is a prevalent issue in this patient population, a substantial portion remains otherwise healthy. For patients undergoing PCNL, there is a wider variety of comorbidities conditions. While a considerable number of these patients also had no comorbidities, hypertension still plays a key role, either on its own or in combination with other conditions such as diabetes mellitus and chronic renal failure. Other comorbidities such as tuberculosis and hyperlipidemia are less frequent but still present. The varied comorbidities in both groups highlight the importance of individualized treatment approaches, as these underlying health issues can affect both the choice of treatment and the patient's response to therapy.

Furthermore, it should be noted that the formation of kidney stones may also be associated with underlying diseases such as diabetes, hypertension, and other dietary factors. Therefore, these people are more susceptible to urinary tract infections as well as kidney stone formation.[16] Therefore, kidney stones should not only be seen as a harmless symptom or merely as a disorder in the urinary system.[17] Epidemiological studies have highlighted its association with conditions such as obesity, metabolic syndrome, diabetes, hypertension, cardiovascular disease, and chronic kidney disease.[18-22] In this study, individuals with diabetes had a higher risk of developing kidney stones; this finding is in line with many other studies.[13,23-26] Weinberg *et al*. (2014) also noted that the severity of type 2 diabetes is a significant risk factor in the development of kidney stones. The relationship between diabetes and kidney stones is explained by the expression of insulin receptors in the renal tubular epithelium, where insulin plays a role in removing ammonia from the renal tubules. As a result, the urine becomes more acidic and increases the susceptibility to the formation of kidney stones.[27,28] Another study revealed that controlling sugar levels increases the risk of kidney stone formation beyond insulin resistance.[29] Poor control of glycemic levels increases urinary calcium levels and ultimately leads to the formation of calcium stones. Apart from the aforementioned pathophysiologies, the formation of kidney stones in patients with diabetes mellitus may be influenced by hypocitraturia, hyperoxaluria, and hyperphosphaturia.

In a cross-sectional study in Europe and a prospective study, it was reported that patients with hypertension had a higher risk of kidney stone formation.[23,30] This was reaffirmed by a prospective study that describes that kidney stone episodes were significantly higher in patients with hypertension.[31] This is in line with the findings in this study, where hypertension was

identified as an additional risk factor for kidney stone formation. This relationship was also observed in previous research, which explained that metabolic acidosis and hypocitraturia conditions in individuals with hypertension significantly affect kidney stone formation.[25,32]

Both PCNL and RIRS have the same goal: stone-free conditions in patients. Apart from providing proper counseling to ensure the patient is well-informed to provide consent, this is also important for decision-making by the surgeon, planning the correct procedure, and aftercare. Therefore, it is necessary to have an available tool to predict the risk of complications in achieving stone-free in patients, and several scoring systems have been developed.[33,34] Among available scoring systems, Guy's stone score (GSS) is the most widely accepted, applied, and validated.[35] To further support this, a study involving 100 PCNL patients concluded that GSS was an accurate predictor of SFR.[36,37]

In this study, the PCNL procedure resulted in an overall SFR of approximately 70%. This is similar to a prospective study performed in Iran, which showed that the overall SFR for PCNL procedures reached 89%, whereas at GSS Grade 1 an SFR was obtained at 100%; at GSS Grade 2, an SFR was obtained at 95.8%, at GSS Grade 3 an SFR was obtained at 80% and GSS Grade 4 with SFR 66.6%.[36] In other studies, the SFR value using the GSS scoring system in kidney stone patients undergoing PCNL varied between 62% and 92%.[36,38,39] In a study Lopez Silva *et al*. (2022) where the operator was a surgeon who was still in residency, it was shown that GSS could be used to determine SFR in patients undergoing PCNL, with an SFR of 77.72%.[40] In addition, the results of this study aligns with previous literature stated, which shows that GSS is a scoring system that can be used to predict SFR, where stones with higher GSS consequently reduce the SFR. GSS is a scoring system that is simple and easy to apply and can be an objective tool for urologists in making clinical decisions and providing assertion to patients in regard to their prognosis.[36] According to the European Association of Urology (EAU) Guidelines on Urolithiasis and the American Urological Association Endourology Society Guidelines state that in treating kidney stones, PCNL is the first choice for therapy for kidney stones with a size >2 cm.[41] In addition, although RIRS is recommended as a second choice for stones >2 cm, it is recommended as a first choice for renal pelvic stones <2 cm by the EAU Urolithiasis Guidelines.[3,4] This is similar to the Guideline for Clinical Management of Urinary Tract Stones by the Indonesian Association of Urologists, where kidney stones in all locations, except for inferior calyx stones, with sizes larger than >2 cm can be operated on primarily with PCNL, followed by extracorporeal shockwave lithotripsy (ESWL), RIRS, then open surgery. In cases of uncomplicated stones, RIRS is not recommended as a first-line treatment due to the lower SFR, which may require repeat procedures. However, RIRS may be the first choice if PCNL is contraindicated. Stones 1–2 cm can be treated with RIRS, ESWL, or PCNL. For stones <1 cm, ESWL or RIRS is superior and should be considered before PCNL.[1]

Stones in the inferior calyx require special treatment. If no inhibiting factors exist, such as stone types that are resistant to shockwaves, steep infundibulum-pelvic angle, or inferior calyx size of >10 mm, then the stone is better treated with SWL RIRS or PCNL. However, RIRS or PCNL can be considered if there are inhibiting factors, even if the stone size is smaller. Stones measuring up to 3 cm can also be treated with RIRS, although repetition of the procedure is often required.[1] With improved technology and increasing surgical experience, RIRS is one of the treatment options for managing larger renal pelvic stones. There are limited studies related to this topic in the literature, and most of them have compared PCNL and RIRS in the management of lower pole renal stones.[42-45]

In this study, the SFR in patients undergoing RIRS treatment overall reached 56%, where if detailed further, there was one patient with Guy's score Grade 1 with an SFR of 100%, there were eight patients with Guy's score Grade 2 with SFR of 63%, there were four patients with Guy's score Grade 3 with SFR of 50%, and there were three patients with Guy's score Grade 4 with SFR of 33%. This aligns with many studies describing higher SFR in patients with PCNL compared to RIRS.[44,46,47] However, research has shown that RIRS is a promising option for managing large kidney stones, offering a relatively high SFR (80.6%) and low complication rates.[44,47]

A systematic review and meta-analysis compared the success rates of SFR between PCNL and RIRS. While standard PCNL demonstrated higher SFR, it was also linked to a greater risk of complications, increased blood loss, and longer hospital stays. Meanwhile, RIRS may provide a higher SFR than mini-PCNL or micro-PCNL and can be considered the standard therapy for stones <2 cm.[48] Most studies that discuss the level of SFR in patients undergoing PCNL and RIRS procedures only explain that SFR is assessed as the condition of no stones or residual fragments <3 mm which do not cause symptoms based on the results of a CT scan

1 month after surgery.[47] Currently, only one study has compared the GSS in patients undergoing PCNL and RIRS, reporting SFRs of 90.3% for PCNL and 58.4% for RIRS.[49] Further prospective research is necessary to support these findings.

The limitations of this study include its retrospective design, single-center setting, and small sample size, particularly for the RIRS group, which limits the generalizability and statistical power of the findings. Despite these limitations, the study is important as it provides useful insights into the clinical outcomes of PCNL and RIRS in treating kidney stones in Indonesia. It highlights key differences in the effectiveness of these procedures based on stone size, helping to inform treatment decisions in similar clinical settings.

Conclusion

This study concludes that PCNL has a SFR of 70% and is most effective in patients over 40 years old with kidney stones larger than 2 cm, typically without significant comorbidities. In contrast, RIRS has an SFR of 56% and is more effective in patients over 40 years old with stones smaller than 2 cm, often accompanied by comorbidities such as hypertension and diabetes. In both procedures, the SFR decreases as the Guy's stone score increases. The study highlights the need for further research with larger sample sizes and more comprehensive data to improve kidney stone management and assess the effectiveness of these treatments.

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Conflicts of interest

There are no conflicts of interest.

Author contribution

MFF and TD were responsible for the concepts, design, definition of intellectual content, literature search, and manuscript preparation, while MAS and MFMS contributed to the design, intellectual content, literature search, data analysis, manuscript editing, and manuscript review. TD and MAS were involved in the clinical studies, with MAS also contributing to experimental studies. MFF handled data acquisition, while TD and MFMS took part in statistical analysis. Manuscript editing was a collaborative effort between MFF, TD, MAS, and MFMS, with TD serving as the guarantor.

Data availability

The data is available upon request from the corresponding author.

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