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Retrograde Intrarenal Surgery and Percutaneous Nephrolithotomy for The Treatment of Renal Stones Greater Than 2 Cm

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ABSTRACT

Background: Stone size is a key factor in the determination of the success of treatment modalities. Recently, there has been a great advancement in technology for minimally invasive management of urinary stones such as percutaneous nephrolithotomy, ureteroscopy, shockwave lithotripsy, and retrograde internal Surgery.

Aim of the Study: to assess and compare the efficacy of retrograde intrarenal surgery (RIRS) in the treatment of kidney stones greater than 2 cm versus percutaneous nephrolithotomy (PCNL).

Patients and methods: A retrospective analysis was carried out for a total of 118 patients, of which 46 patients underwent RIRS while 72 patients underwent PCNL between May 2013 and May 2017.

Results: The mean duration of operation was 96.39±41.11 min in the RIRS group and 69.51±19.3 min in the PCNL group ($p<0.001$). Hospital stay was significantly shorter in the RIRS group (1.32±0.6 vs. 4.19±1.9 days) in the RIRS and PCNL groups respectively ($p<0.001$). Stone-free rates after one session were 67.4% and 90.3% of the RIRS and PCNL groups, respectively. Blood transfusions were required in two patients in the PCNL group. Complication rates were generally higher in the PCNL group.

Conclusion: The present study concluded that RIRS can be a successful substitute to PCNL in the treatment of kidney stones with a diameter of 2–4 cm particularly in patients with comorbidities.

Keywords: Percutaneous nephrolithotomy, retrograde intrarenal surgery, renal stones, flexible ureteroscopy.

INTRODUCTION

Renal calculi are formed when the urine is supersaturated with salt and minerals such as calcium oxalate, struvite (ammonium magnesium phosphate), uric acid and cysteine [10].60-80% of stones contain calcium[2].They vary considerably in size from small 'gravel-like' stones to large staghorn calculi. The calculi may stay in the position in which they are formed, or migrate down the urinary tract, producing symptoms along the way. Studies suggest that the initial factor involved in the formation of a stone may be the presence of nano -bacteria that form a calcium phosphate shell[3].

The primary goal while treating renal stones is to achieve maximum clearance of stone, while causing minimal morbidity to the patient.

The treatment of urinary calculi has advanced considerably with the development of instruments and techniques. Most patients with renal and ureteric calculi presenting to a urologist require treatment. The currently available options include ESWL, percutaneous nephrolithotomy (PCNL), and ureteroscopic lithotripsy (UL). Open and laparoscopic surgery are reserved for rare, special cases [4].

Once the decision to treat the stone has been made there must be a decision on which technique to use. This is based on the success and the morbidity of any individual procedure, which in turn is based on the location and size of the stone, as well as the patient's comorbidities. The preferred approach for stones >1 cm is SWL, whereas for stones <2 cm, it is PCNL, but the management of stones of 1-2 cm is still controversial[5].

Percutaneous nephrolithotomy (PCNL) is the mainstay of management for large (> 2 cm) or complicated renal stones [6]. Although this technique affords high success rates and accelerated stone clearance, regardless of stone composition and size [7], it is an aggressive treatment with severe complications especially for patients with solitary kidney. Such patients are likely to have increased thickness of the renal parenchyma as a consequence

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of the compensatory hypertrophy, thus they are more likely to suffer bleeding when treated with PCNL more than patients with bilateral kidneys [8]. In addition, significant bleeding in these patients means potential acute renal failure due to urinary obstruction by blood clots and the absence of supplementary renal function of the other kidney [9]. Perhaps anatomically oriented access can be made so that the risk of this complication is minimized, but cannot be totally avoided.

In the past few years, improvements in endoscopy technology make retrograde intrarenal surgery (RIRS) more attractive, even for special circumstances, which has been used as an alternative option to PCNL for renal stones with a low complication rate [6]. In patients contraindicated for PCNL and with unfavorable treatment characteristics, such as morbid obesity, advanced vertebral deformities, serious cardiopulmonary diseases or those receiving anticoagulant treatment, RIRS is a reliable choice [6], which is a preferable treatment method for preserving functioning renal parenchyma[10]. Unfortunately, RIRS cannot be recommended as first-line treatment due to which stone-free rate (SFR) showed a negative correlation with stone size [11]. SFR after RIRS was achieved in 30% of patients with >2 cm stones and usually needed re-treatment; however, overall complication rates are not related to stone sizes [11]. Thus, patients with larger than 2 cm stones must be counseled independently as staged procedures usually required to take away calculi from the kidney without compromising the safety of RIRS. Recently, Kuroda *et al.*[10]have shown that no significant difference was found in term of the change in glomerular filtration rate after RIRS between patients with solitary kidney and bilateral kidneys.

MATERIALS AND METHODS

Our retrospective review included a total of 118 patients presented to our clinic and underwent PCNL (72 patients, 53 males and 33 females) or RIRS (46 patients, 29 males and 17 females) between May 2013 and May 2017. It's important to mention that patients with renal failure, history of previous pyelonephritis, preoperative diagnosis of a renal scar, and morbidly obese patients and those by whom multiple access was required during surgery were excluded in the present study.

Demographic data of the patients, the size and the site of stones, the duration of operation, stone free rates, and the duration of the hospital stay were analyzed and reported.

On the other hand, stone-free state was determined at the postoperative third month on computerized tomography (CT).

Moreover, complete blood count, serum creatinine, bleeding and clotting times, and urine culture of the patients were analyzed. Patients with a positive urine culture had surgery after treatment with antibiotics for an appropriate duration. All patients had X-Ray direct urinary system X-ray or urinary system ultrasonography and spiral CT without contrast. Before surgery, all patients signed informed consent forms. The stone size was determined as the surface area calculated according to the guidelines of European Association of Urology[12].

For RIRS group , a guidewire and a ureteral access sheath (11 or 12 F) were placed into the ureter and the procedure was performed using a Storz FLEX-X2 ureterorenoscope (Tuttlingen, Germany). A holmium laser device was set at the energy of level 1.0–2 J and the rate of 5–10 Hz. Later, stone-free rates were followed up in the outpatient clinic at the postoperative third month, with low-dose spiral CT.

As for PCNL group , a standard conventional PCNL was used. Standard treatment included dilatation with standard Amplatz dilatation equipment, a nephroscope (26 F Storz; Karl Storz GmbH & Co. KG, Tuttlingen, Germany), and a pneumatic lithotripter (Vibrolith®, Elmed, Ankara, Turkey) were used for stone fragmentation. The procedure was done using a C-arm X-ray device (PHILIPS BV ENDURA, Netherland). All PCNL procedures were carried out in the standard prone position.

Complications were scored according to the modified Clavien-Dindo classification in two groups[13]. Group 1 consisted of grade 1 and grade 2 complications and was classified as the "minor complication group," whereas group 2 consisted of grade 3, 4, and 5 complications and was classified as the "major complications group." The most common complication was postoperative fever (Modified Clavien 1) and was observed in nine patients in group 1, where it regressed after medical therapy. This complication was not observed in group 2. There

was a need for blood transfusion in nine patients in group 1 (Modified Clavien 2) but not in any of the patients in group 2. In both groups, additional treatment was required because of stone street (steinstrasse) in two patients of each group (Modified Clavien 3b).

The study was done after approval of ethical board of King Abdulaziz university.

Statistical analysis

Statistical analysis was carried out according to the Statistical Package for the Social Sciences 18.0 program (SPSS for Windows, Chicago, IL, USA).

The following methods were used:

1. Chi-square test ($\chi 2$ test) for comparisons of the categorical variables.
2. Student's t-test for the comparison of the two groups.
3. Pearson correlation analysis for correlations analysis among the variables.

Confidence interval was set at 95% and $p<0.05$ was considered statistically significant.

RESULTS

There was a total of 118 patients: 46 patients in the RIRS group and 72 patients in the PCNL group .Comparison between both groups was reported in terms of size, location, and number of the stone(s); age; gender of the patient; history of open surgery or ESWL; degree of hydronephrosis; duration of hospital stay; stone-free rates; and complications. Both groups showed statistically significant differences in history of surgery, localization of the stone, and mean stone size; however, they were similar in the other parameters examined (Table 1).

Table 1: demographic characteristics of the patients included with the characteristics of the stones per group

	Parameters	RIRS	PCNL	p
Patient's demographic characteristics	Number of patients	46	72	
	Mean age	39.04±11.56	49.12±11.31	0.271
	Gender			
	Female	17 (37.0%)	33 (38.4%)	0.683
	Male	29 (64.9%)	53 (61.6%)	
History of Open Surgery	(−)	16 (35.3%)	7 (10%)	0.002
	(+)	30 (64.7%)	65 (90%)	
	History of ESWL			
	(−)	5 (10.8%)	6 (8.4%)	0.643
	(+)	41 (89.2%)	66 (91.6%)	
Degree of hydronephrosis	None or mild	49 (87%)	52 (72.2%)	0.174
	Moderate or severe	6 (13%)	20 (27.8%)	
	Number of stones			
	One	15	27	0.51
	Multiple	31	45	
	Localization of stone			
	Upper calyx	9	0	
	Middle calyx	8	8	
	Lower calyx	13	15	<0.001
	Pelvis	10	39	
	Complex	6	10	
	Mean stone size (cm)	2.47±0.61	3.09±0.64	<0.001

The difference in the mean duration of surgery was statistically significant (p<0.001) with a mean of 96.39±41.11 min in the RIRS group and 69.51±19.3 min in the PCNL group.

It was observed that all complications were pronouncedly detected in the PCNL group, with statistically significant differences. Blood transfusions were required for two patients in the PCNL group, nevertheless, none of the patients in the RIRS group needed blood transfusions. None of the patients in the PCNL group developed for or pneumothorax. Postoperative fever was observed in seven patients in the PCNL group; however, no patients in the RIRS group experienced such complication. The patients with postoperative fever were administered antibiotics according to their urinary culture results. Stone street (steinstrasse) formation was seen in two patients in the RIRS group and in two patients in the PCNL group who later underwent ureter stone surgery using a rigid ureteroscope in a separate session.

The mean hospital stay was significantly shorter in the RIRS group 1.32±0.6days in the RIRS group while it was 4.19±1.9days in the PCNL group (p<0.001). The stone-free rate in the RIRS group was 67.4% vs 90.3% in the PCNL group (Table 2).

Table 2: Outcome and complications of RIRS group versus PCNL group

Parameters	RIRS(n=46)	PCNL (n=72)	p
Duration of surgery (min)	96.39±41.11	69.51±19.3	<0.001
Hospital stay (days)	1.32±0.6	4.19±1.9	<0.001
Postoperative amount of fall in hemoglobin (g/dL)	0.41±0.40	2.18±1.24	<0.001
Complications			
Fever	0	7	0.12
Blood transfusion	0	2	0.24
Stone street	2	2	0.54
Number of patients with residual stones	15(67.4%)	7 (90.3%)	<0.001
Postoperative increase in creatinine	-	-	

DISCUSSION

Urinary stones are the third most common affliction of the urinary tract. They are exceeded only by urinary tract infections and pathologic conditions of the prostate [14].

The reported prevalence rate of stone disease is 5%-12% in men, 4%-7% in women[15].Stone formation is affected by gender, age and geography. Recent studies indicated a rise in the prevalence of urinary stones, and this rise comprised in all gender, racial and ethnic ensemble in the United States[16].

Eating habits and environmental conditions also have major roles in the formation of urinary stones. Diabetes mellitus (DM), gout, and obesity are closely associated with urinary stone formation[17].

Children represent about 1% of all patients with urolithiasis, who have a almost 100% risk for recurrent stone formation. Both in adults and in children, stone size and location, other factors, including stone composition, patient factors, and renal anatomy, can influence the success of specific treatment modalities [18].

The aim of the urinary stone treatment is achieving the highest stone-free rate with the lowest morbidity. Thus, currently, less invasive endourological methods are used in urinary stone treatment.

Percutaneous nephrolithotomy (PNL) is currently the first-line recommended treatment for large kidney stones ≥ 20 mm[19].PNL yields an excellent stone-free rate for large kidney stones. However, its invasiveness is not negligible due to its considerable major complication rates. Although the puncture and dilation of a nephrostomy tract is an essential

process in PNL, it may induce renal parenchymal damage, blood loss, or visceral injury. A recent global study of PNL reported the major complication rates, which included significant bleeding in 7.8%, renal pelvis perforation in 3.4%, and hydrothorax in 1.8%[20].Blood transfusions were necessary in 5.7% of the patients. Postoperative high-grade fever occurred in 10.5%. The conventional prone position during the surgery may induce the respiratory problems.

RIRS has been frequently considered in the treatment of larger renal stones as an alternative to PCNL. Although hemorrhagic diseases are often regarded as contraindications for both PCNL and SWL, RIRS demonstrated pretty safety in these patients [21].Furthermore, with the increasing numbers of obese and morbid obese patients, the status of PCNL for renal stones may face challenges because great skin-kidney distance in these patients may lead to the puncture needle cannot reach the kidney. Fortunately, RIRS can be executed without limited outcomes for obese patients [22].

In the present study, two of 72 patients in the PCNL group demanded blood transfusion after experiencing bleeding. On the contrary, blood transfusion was not required fpr any of the patients with RIRS even with a long duration of operations. In contrast, high intrarenal pressure during RIRS has been reported to cause temporary intrarenal reflux affecting the renal function[23].

Postoperative creatinine level was not observed in any of the patients included in the current study. Yet, two patients in the RIRS group and similarly 2 patients in PCNL group developed stone street who were treated with a supplementary rigid ureteroscopic procedure. The driver of stone street formation could be the use of a pneumatic lithotripter instead of a holmium laser in the PCNL group which might let large-sized stones to pass spontaneously in the RIRS group. Consistent fragmentation of a greater residual stone burden during RIRS into smaller particles (<1–2 mm) substantially reduces the risk of stone street formation[23].

Hospital stay was longer in the PCNL group when compared to RIRS group. The most important factors accounting for these cases were the nephrostomy catheter placed for drainage, the necessity for analgesia, and the need for follow-up after blood transfusion. Recent studies showed that PCNL procedures performed without tubes decreased the hospital stay significantly[24].In our study, the mean hospital stay was 4.19±1.9days in the PCNL group and 1.32±0.6days in the RIRS group. Similar results in the literature have also indicated that hospital stay was significantly shorter in the RIRS group in comparison with the PCNL group ($p<0.001$) [15].

CONCLUSION

Both PCNL and RIRS provide high success rates in the treatment of lower calyceal kidney stones. RIRS is used as the primary option in morbid obese patients with stones smaller than 2 cm, in patients with musculoskeletal deformities or bleeding diatheses, in patients with the need for complete clearance of kidney stones, and in case of previous unsuccessful ESWL treatment. Currently, PCNL is the gold standard treatment for kidney stones greater than 2 cm. However, single or multi-session RIRS may provide successful results in stones greater than 2 cm. Therefore, RIRS with a holmium laser may be an alternative to PCNL in selected patients with large-sized renal stones. Nevertheless, these results must be confirmed by further prospective randomized trials.

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