Retrograde intrarenal surgery or percutaneous nephrolithotomy in the treatment of impacted proximal ureteric calculi

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Research Article

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Abstract

The objective of this study was to compare the clinical efficacy of retrograde intrarenal surgery (RIRS) and percutaneous nephrolithotomy (PCNL) in the treatment of impacted proximal ureteric calculi. This was a retrospective study on surgical outcomes of 202 patients with impacted proximal ureteric calculi. Overall, 140 and 62 were treated with RIRS and PCNL, respectively. The effects of the choice of the surgical method on the surgical outcomes were evaluated by preoperatively scoring patients with high-risk factors related to stone characteristics and analyzing these scores. Compared to the RIRS group, the surgical duration of the PCNL group was significantly shorter (51.69 ± 25.07 min vs. 67.46 ± 27.12 min, $p < 0.05$), stone-free rate (SFR) was significantly increased (98.4% vs. 72.10%, $p < 0.05$), and total treatment cost was lower (US $1678.61 ± 714.86 vs. US $3901.45 ± 1069.46, $p < 0.05$). Preoperatively, the efficacy of PCNL was higher than that of RIRS based on the higher scores observed. The results indicated PCNL had a better SFR and higher surgical efficacy, whereas RIRS had higher surgical safety parameters, a shorter perioperative period, but a lower initial SFR. PCNL is often more advantageous for complicated impacted proximal ureter stone.

Introduction

Urolithiasis is a common medical condition. Its incidence by the age of 70 years is 11–13% in men and 5.6-7.0% in women [1].Ureteric calculi can adversely affect kidney function and cause life-threatening sepsis [2]. According to the latest urological guidelines, extracorporeal shock wave lithotripsy (ESWL), retrograde intrarenal surgery (RIRS), and percutaneous nephrolithotomy (PCNL) are the most commonly used treatment methods for proximal ureter stones [3], but their associated stone-free rates (SFR) and complication rates differ.

Scoring systems such as the Guy's Stone and the STONE scores have been introduced to evaluate the surgical efficacy on different kidney stone cases [4, 5].Various surgical methods have been used for the treatment of proximal ureteral calculi. Wu *etal.*conducted a meta-analysis and found that RIRS should be regarded as the standard treatment for large proximal ureteral calculi [6]. A retrospective analysis conducted by Bozkurt*etal.*found that PCNL is a safer and more effective treatment for impacted proximal ureteral calculi [7]. Li *et al.* revealed that the treatment options for impacted proximal ureteral calculi depend on the location of the stone relative to the superior boundary of the fourth lumbar vertebra [8]. However, thus far, no scoring systems have been developed to guide the treatment of upper ureteral calculi. In this study, after analyzing the existing data, high-risk factors associated with the characteristics of stones were preoperatively assigned scores, and the better surgical plan for the upper ureteral stones can be decided based on the scores.

Results

Overall, 202 patients with impacted proximal ureteral calculi admitted to our hospital between 2017 and 2020 were included. There was no significant difference regarding age, sex, body mass index, creatinine

level, clinical features of the stones between the RIRS and PCNL groups ($p > 0.05$).(Table-2)

Table-2 Demographic characteristics data of patients according to patients 'group

Parameter	RIRS group N=140	PCNL group N=62	t/χ^2 value	*p*-value
Age	54.40+11.17	52.82+12.58	0.890	0.116
Sex Male/Female	86/54	45/17	2.345	0.126
Body mass index	23.89+3.62	23.67+3.53	0.410	0.782
Creatinine	80.76+27.36	79.91+31.43	0.194	0.787
Stone hardness (1000 HU)	783.60+243.55	960.66+225.01	-4.88	0.649
Stone diameter (mm)	8.65+2.95	10.15+2.94	-3.33	0.759
Site of stones Left/Right	65/75	34/28	1.216	0.270
Preoperative infection Yes/No	40/100	25/37	2.719	0.099
History of SWL treatment Yes/No	35/105	13/49	0.386	0.535

Data are presented as means ± standard deviations (SD) or numbers. Abbreviations: RIRS, retrograde intrarenal surgery; PCNL, percutaneous nephrolithotomy; SWL, shock wave lithotripsy

Overall, the length of hospital stay was significantly longer in the PCNL group than that in the RIRS group, but the surgical duration was significantly shorter and SFR was significantly higher in the PCNL group than in the RIRS group ($p < 0.05$). No secondary procedures such as second look PCNL or RIRS were performed in this series. There was a significant difference in the total cost of treatment between the two groups, with a lower cost in the PCNL group. There was no significant difference in complication rate between the two groups ($p > 0.05$). Based on the modified Clavien grading standards, there were no complications greater than grade IV in the two groups. There were four cases in the PCNL group with grade I complications, all of which had postoperative renal colic that was treated with analgesics, three cases with grade II bleeding complications that required blood transfusion after operation, and one case with grade III severe complications, with severe postoperative bleeding treated with renal artery embolization. There were 15 cases with infection as a postoperative complication in the RIRS group. (Table-3)

Table-3 Intraoperative and Postoperative data according to patients' group

Parameter	RIRS group N=140	PCNL group N=62	*p*-value
Operation time (min)	67.46±27.12	51.69±25.07	0.000
Length of hospital stay (days)	3.68±2.70	8.39±3.34	0.000
Stone-free rate	101(72.10)	61(98.40)	0.000
Complication rate	15(10.7)	8(12.9)	0.651
Total cost of treatment(US $)	3901.45±1069.46	1678.61 ± 714.86	0.000

Data are presented as means ± standard deviations (SD) or numbers and proportions.
Abbreviations: RIRS, retrograde intrarenal surgery; PCNL, percutaneous nephrolithotomy.

After scoring the 202 patients, they were divided into uncomplicated cases (score < 3 points) group and complicated cases (score ≥ 3 points) group (Table 3). By comparing the RIRS and PCNL operation methods between the two groups, we found that in complicated cases(≥ 3 points), the operation time, SFR, and total treatment cost of PCNL were still superior compared with those in the RIRS ($p < 0.05$). There was no significant difference between the complication rates in the two groups with increased scores ($p > 0.05$). (Table-4)

Intra-group comparisons between the uncomplicated cases (score < 3 points) and complicated cases (score ≥ 3 points) of the RIRS and PCNL groups respectively are shown in Table 4. The operation time, length of hospital stay, cost of hospital stay, SFR, and complication rate in the complicated cases of the PCNL group were not significantly different compared with those in the uncomplicated cases of the PCNL group ($p > 0.05$). In the RIRS group, although the operation time was longer and complication rate was higher in the complicated cases (score ≥ 3 points), the results were not statistically significant ($p > 0.05$). The length of hospital stay increased in the complicated cases (7.20 ± 3.14 d) compared with the uncomplicated cases (3.59 ± 2.65 d), and the SFR was decreased from 78.3% in the uncomplicated cases to 35% in the complicated cases ($p < 0.05$). There was no significant increase in the cost of treatment between the two groups when the score was increased. (Table-5)

Table 4
Comparisons of the perioperative data between the uncomplicated cases and complicated cases of the RIRS and PCNL groups

Parameter	**Uncomplicated case group (score < 3)**		***p*-value**	**Complicated case group (score ≥ 3)**		***p*-value**
	RIRS group N = 120	PCNL group N = 35		RIRS group N = 20	PCNL group N = 27	
Operation Time(min)	66.45 + 26.77	50.63 + 26.19	0.002	73.50 + 29.12	53.07 + 23.95	0.011
Length of hospital stay (days)	3.59 + 2.65	7.91 + 3.48	0.000	7.20 + 3.14	9.00 + 3.11	0.057
Cost of hospital stay(US $)	3885.19 + 1053.94	1652.89 + 831.53	0.000	3998.96 + 1182.95	1711.86 + 541.04	0.000
Stone-free rate	94(78.3)	35(100)	0.003	7(35)	26(96.3)	0.000
Complication rate	11(9.2)	2(5.7)	0.517	4(20)	6(22.2)	0.854

Data are presented as means ± standard deviations (SD) or numbers and proportions.

Abbreviations: RIRS, retrograde intrarenal surgery; PCNL, percutaneous nephrolithotomy.

Table 5
Intra-group comparisons of the perioperative data between the uncomplicated cases and complicated cases of the RIRS and PCNL groups

Parameter	RIRS group		*P* - value	PCNL group		*P* - value
	Uncomplicated case group (score < 3) N = 120	Complicated case group (score ≥ 3) N = 20		Uncomplicated case group (score < 3) N = 35	Complicated case group (score ≥ 3) N = 27	
Surgical duration (min)	66.45 + 26.77	73.50 + 29.12	0.283	50.63 + 26.19	53.07 + 23.95	0.707
Length of hospital stay (days)	3.59 + 2.65	7.20 + 3.14	0.000	7.91 + 3.48	9.00 + 3.11	0.207
Cost of hospital stay(US $)	3885.19 + 1053.94	3998.96 + 1182.95	0.661	1652.89 + 831.53	1711.86 + 541.04	0.750
Stone-free rate	94(78.3%)	7(35%)	0.000	35(100%)	26(96.3%)	0.251
Complication rate	11(9.2%)	4(20%)	0.147	2(5.7%)	6(22.2%)	0.055
Data are presented as means ± standard deviations (SD) or numbers and proportions.						
Abbreviations: RIRS, retrograde intrarenal surgery; PCNL, percutaneous nephrolithotomy.						

Discussion

The choice of management for impacted proximal ureteral calculi has been controversial for a long time, but the ultimate goal is for patients to be completely stone-free and to avoid complications. Some clinical factors may play important role, in addition to experience of the surgeon and the choice of treatment [15–16].

Retrograde intrarenal surgery mainly includes semi-rigid ureteroscopy and flexible ureteroscopy. RIRS is generally safe and provides rapid postoperative recovery, but RIRS also has significant disadvantages. Poor irrigation control leads to stone fragments being flushed backward into the renal collection system.

Urinary tract infections and ureteral strictures are serious complications of RIRS, and severe cases can lead to urosepsis and even septic shock [15]. The main mechanism of infection is high intraoperative irrigation pressure, resulting in the reflux of bacterial endotoxins into the circulation system [17, 18].Study has showed that the use of ureteral access sheaths (UAS) can significantly decrease intro-renal pressure during RIRS [18]. Holmium laser lithotrispy increases the risk of ureteral stricture [19]. Fam*et al.* reported that the incidence of ureteral stricture after operation is 3–24% [20]. Ureteral stricture can be caused by thermal damage during holmium laser lithotripsy. Thermal effect can damage epithelial structure and blood supply of the ureter wall [21]. However, no patients with ureteral stricture after RIRS were identified in the present study.

The advantage of PCNL lies in its high SFR; Gdor*et al.* found that the success rate of ureteroscopy in the treatment of impacted ureter stones is only 56% [22].

PCNL has advantages in both the initial and overall stone clearance efficiency when compared to RIRS. Study has shown that the adjuvant surgery rate of RIRS is also much higher than that of PCNL [17]. PCNL also has many serious complications such as damage to the adjacent organs, hemorrhage and severe postoperative infections [23–26].

There are many treatment methods for impacted proximal ureteral calculi. In order to achieve better surgical outcomes, preoperative risk factors associated with calculi can be screened for and scored into different groupings. Kokov*et al.* studied the size of stones as the only independent predictor of stone-free status after percutaneous nephroscopy[10]. A prospective study by Gucuk*et al.* indicated that stone density is a parameter that significantly impacts SFR [11]. Yuruk*et al.* found that previous ESWL could affect PCNL efficacy and make the operation more difficult [12]. Kadihasanoglu *et al.* showed that hydronephrosis is the main factor affecting SFR after PCNL [13].Haas found that delayed decompression in patients with obstructive calculi complicated with urinary tract infection was associated with an increased risk of death. [14]. Based on the findings from the previous studies, five preoperative stone-related high-risk factors (stone diameter, stone hardness, history of previous lithotripsy, and degree of hydronephrosis, infection) were selected for evaluation and analysis in the present study.

After scoring and grouping preoperative high-risk factors of the stones, the patients were classified as uncomplicated cases (score < 3 points) group and complicated cases (score ≥ 3 points) group, perioperative data were compared between and within groups in both PCNL and RIRS cases. In the complicated cases, the operation time, length of hospital stay, and complication rate of RIRS significantly increased, whereas SFR gradually decreased. These findings indicate that the efficacy of RIRS on complicated cases is low. The advantage of the short duration of the hospital stay in the uncomplicated RIRS cases no longer existed, and surgical efficacy was significantly decreased.

The present study has some limitations. First, the study was a retrospective analysis that was conducted among patients enrolled at a single center. Second, the number of patients included was relatively small. A prospective, multi-center, randomized controlled trial will be expected in the future to validate the scoring system.

In conclusion, for impacted proximal ureter stone, PCNL had a better SFR and higher surgical efficacy, whereas RIRS had higher surgical safety parameters, a shorter perioperative period, but a lower initial SFR. Both methods are effective in treating uncomplicated impacted proximal ureter stone; but PCNL is often more advantageous for complicated cases (score ≥ 3 points). Thus, when choosing a better treatment method for complicated impacted proximal ureteral calculi, we believe that PCNL is the preferred choice over RIRS.

Methods

Study design

A total of 202 patients with impacted proximal ureteral stones eligible for treatment between January 2017 and April 2020 were included in the study. According to the Chinese urological guidelines, the proximal ureter is defined as the area from the junction of the renal pelvis and ureter to the upper edge of the sacroiliac joint (or the lower edge of the fourth lumbar vertebra), confirmed using imaging segmentation as a reference[9]. The inclusion criteria for impacted calculi are as follows: the stone has been retained in the ureter for at least 4 weeks; previously failed ESWL; hydronephrosis in the ipsilateral renal pelvic collecting system is over 1 cm; and ureteral stricture or polyp formation near the stone. Patients who met any two of these criteria were diagnosed with impacted proximal ureteral calculi. Exclusion criteria included the following: Previous history of open operation of ipsilateral ureter and kidney; patients requiring treatment for kidney stones or bilateral ureteric stones at the same time; patients with solitary kidney, and other renal abnormalities; and patients who were lost to follow-up during the study period.

All patients underwent preoperative computed tomography (CT) examination of the urinary system; urinalysis, urine culture, blood count, coagulation function and creatinine levels. Prophylactic antibiotics were preoperatively administered in all patients, and those with positive urine cultures were treated with sensitive antibiotics to control infection.

Surgical procedures

RIRS:

For the semi-rigid ureteroscopic lithotripsy procedure, patients were placed in the lithotomy position under epidural or general anesthesia. An 8/9.8-F semi-rigid ureteroscope was advanced into the ureter via a safety guidewire. After the location of the stone was determined, it was directly managed by using a pneumoballistic or holmium laser.

For the flexible ureteroscopic lithotripsy, after successfully anesthetizing the patients, a holmium laser fiber was placed via a flexible ureterscope for stone fragmentation. Stone removal baskets were used routinely in RIRS surgery to improve stone removal efficiency. A 6F D-J tube was routinely placed after the operation.

PCNL:

Patients were placed in the lithotomy position, and artificial hydronephrosis was induced after epidural or general anesthesia. After inserting the ureteral catheter, patients were turned to the prone position, and the target renal calyx was punctured under ultrasound guidance. A fascial dilator was used to continuously expand to the desired working tract.

After advancing the nephroscope via the guidewire and determining the location of the stone, ultrasonic and pneumatic lithotripsy were usedto break the stone and remove the stone fragments.
A 6F D-J tube was routinely placed, and a nephrostomy tube was placed at end of the operation.

All operations were completed successfully and at one time, and there was no conversion to open surgery and secondary surgery. All patients who met the inclusion criteria were followed up within 3 months after operation to evaluate clinical efficacy. Demographics data, preoperative high risk factors, and perioperative parameters were evaluated and compared between the groups. The degree of hydronephrosis was determined by measuring the anterior and posterior diameter of the hydronephrosis on CT. Hydronephrosis less than 2 cm was considered moderate. Surgical duration was defined as the time from placing the patients in the lithotomy position in the RIRS group or placing the patients in the prone position in the PCNL group to the end of anesthesia. The SFR was defined as no residual stones on the urinary CT scan postoperative. Complications were analyzed using a modified Clavien classification; infectious complications were defined as postoperative Systemic Inflammatory Response Syndrome (SIRS) symptoms and bleeding complications were defined as postoperative blood transfusion and renal artery embolization. All patients underwent CT examination at 1 month postoperative to determine whether there were residual stones, ureteral stenosis, or hydronephrosis.

The definition and scoring standards for preoperative high-risk factors associated with stones were selected based on findings from existing literature. These high-risk factors included whether the diameter of the stone was > 2 cm [10], stone density was > 1000 HU [11], there was a history of lithotripsy [12], the degree of hydronephrosis was greater than moderate [13], and there was infection [14]. Scores for high-risk factors associated with stones were then assigned (yes = 1, no = 0). Complicated stone case was defined as total stone score ≥ 3; uncomplicated stone case was defined as total stone score < 3(table-1).Group analysis was performed based on the stone scores to determine the effect of the choice of the surgical method on surgical outcomes.

Due to the retrospective nature of the study, the need for informed consent was waived; additionally, the study design was approved by the ShengJing hospital ethics review board. Authors had no access to information that could identify individual participants during or after data collection. All clinical investigations were conducted according to the principles expressed in the Declaration of Helsinki.

Table-1 The definition and scoring standards for preoperative high-risk factors associated with stones

Variables	yes	no
Sever Hydronephrosis	1	0
Density of the stone Over 1000 HU	1	0
Diameter of the stone Over 2cm	1	0
Infection	1	0
History of SWL , RIRS or PCNL of the same stone	1	0

Abbreviations: RIRS, retrograde intrarenal surgery; PCNL, percutaneous nephrolithotomy; SWL, shock wave lithotripsy

Statistics analysis

Continuous data were described as means ± standard deviations (SD), and count data were described as frequencies (number). SPSS 23.0 software was used for statistical analysis. The t-test for independent samples was used to compare differences between the two groups depending on the normality and homoscedasticity of continuous data. Additionally, the four-grid chi-square test was used to compare the distribution differences of rates or composition ratios between the two groups. Differences with $p < 0.05$ were considered statistically significant.

Abbreviations

PCNL=percutaneousnephrolithotomy;

CT=ComputedTomography;

BMI=body mass index;

RIRS=retrograde intrarenal surgery;

SWL=shock wave lithotripsy.

Declarations

Funding: No funding

Conflicts of interest: The authors declare that there are no conflicts of interest.

Ethics approval: the study design was approved by the ShengJing hospital ethics

review board.

Consent to participate: Due to the retrospective nature of the study, the need for

informed consent was waived

Consent for publication: The study was approved by the ShengJing hospital ethics

committees for Consent for publication

Availability of data and material: Supporting data can be accessed via the hospital database by contacting the corresponding author upon request.

Authors' contributions:

LV Wen Zhang: Data collection, manuscript writing

Yan Song:Study design,supervision

Xiang Fei:Data analysis,manuscript writing

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