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Original Article

Flexible ureterorenoscopy versus percutaneous nephrolithotomy in the semisupine-lithotomy position for treatment of lower pole renal stones of 10-20 mm

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Abstract: Purpose: The aim of this study was to compare the clinical therapeutic effects of flexible ureteroscope lithotripsy (FUL) and percutaneous nephrolithotripsy (PCNL) in the semisupine-lithotomy position for unilateral lower pole calculi with a diameter of 10-20 mm. Patients and methods: A total of 83 patients with unilateral lower pole calculi with a diameter of 10-20 mm were prospectively analyzed from January 2016 to April 2018. A total of 38 cases were treated with PCNL in the semisupine-lithotomy position (PCNL group), while 45 cases were treated with FUL (FUL group). Operative time, hospitalization time, hemoglobin decrease after the operation, success rate of lithotomy, complications, and economical costs were compared between the 2 groups. Results: Treatment was completed successfully in the 2 groups. No serious complications (Clavien III-V) occurred in either group. Stone-free rate of FUL was 88.1%, while that of the PCNL group was 93.8. There were no statistically significant differences ($P = 0.07$). Operative times and economical costs in the FUL group were significantly higher than those in the PCNL group: (107.8 ± 28.74) min vs. (67.7 ± 20.42) min and (14,605 ± 1,754) yuan vs. (20,142 ± 2,759) yuan. Hemoglobin decreased after the operation and postoperative hospital stay times were significantly lower than those in the PCNL group: (0.65 ± 0.39) g/L vs. (6.12 ± 3.94) g/L and (4.92 ± 0.68) days versus (6.84 ± 1.48) days. There were statistically significant differences ($P < 0.001$). Conclusion: Implementation of PCNL in the semisupine-lithotomy position and FUL for treatment of lower pole renal calculi 10-20 mm is feasible and safe. Success rates of lithotripsy of the two groups are similar. FUL has less trauma and economical costs, with shorter hospitalization times.

Keywords: Renal calculi, percutaneous nephrolithotomy, flexible ureteroscopic lithotripsy, semisupine-lithotomy position, complications

Introduction

Epidemiological investigations have shown that kidney calculi patients account for 45%~55% of patients with urinary calculi, including more than a third of lower calyceal stones [1, 2]. With a diameter of kidney stones more than 20 mm, the European Association of Urology (EAU) in 2017 and China Urology Disease Diagnosis and Treatment Guidelines in 2014 have recommended percutaneous nephrolithotomy (PCNL) treatment for < 10 mm renal calyx calculi preferred carried extracorporeal shock wave lithotripsy (ESWL) [3, 4]. Part of asymptomatic lower pole renal calyx calculi carried conservative treatment. However, there are nearly a third of lower pole stones leading to risk of bilateral hydronephrosis and pain [5, 6], ESWL treatment for renal lower calyx calculi rarely achieves the ideal treatment effect, requiring medication or surgical intervention. Therefore, more than 10 mm lower pole stones often require cavity treatment for symptomatic calculi (PCNL and FUL). The special anatomical location of the renal inferior calyx, diameter of the calyx neck, length of calyx diameter, and other factors influence clinical treatment effects of the renal inferior calyx stones [7].

The current study presents a retrospective comparative clinical study of FUL versus PCNL in the semisupine-lithotomy position for treatment for isolated lower pole stones of 10-20 mm.

Table 1. Demographic data

	PCNL	FUL	*P* value
No. of patients	38	45	-
Male/female (n)	22/16	28/17	-
Age (Mean ± SD) (years)	45.10 ± 10.53	36.28 ± 10.43	0.61
Median BMI	31.5	29.3	0.32
Side of stone			0.68
Left	17	23	
Right	21	25	
Median stone burden (mm) (range)	15.5 ± 3.1 (11-20)	14.2 ± 4.4 (10-19)	0.18

SD: standard deviation. BMI: body mass index, PCNL: percutaneous nephrolithotomy, FUL: flexible ureteroscopic lithotripsy.

Figure 1. Semisupine-lithotomy position.

Patients and methods

Patients

From January 2016 to April 2018, 83 patients with lower pole calculi, between 10-20 mm, as estimated by X-ray of kidney-ureter-bladder (KUB films), were included in this study. They were treated with FUL (Group 1: 45 patients) and PCNL (Group 2: 38 patients) by the same surgical team.

Preoperative examinations for patients consisted of blood and urine routine examinations, hepatic and renal function tests, coagulation function tests, bacterial culture of urine, X-ray examinations, and electrocardiograms. Patients with white blood cells increased in the urine or positive urine bacteria culture were treated with antibiotics pre-operation.

Patient inclusion and exclusion criteria were as follows: (1) Imaging series included abdominal plain film (KUB), intravenous pyelography (IVP), color Doppler ultrasound and/or CT plain scan of uropoietic system for the diagnosis of unilateral kidney under single stone. The longest diameter of the stone was 10 to 20 mm, light to moderate hydronephrosis and normal renal function (serum creatinine values men < 97 umol/l, women < 73 umol/l) line of surgical treatment of patients; (2) Elimination of lateral renal and ureter abnormal anatomy and abnormalities (for example ectopic kidney, rotation anomaly, horseshoe kidney, etc.), trauma surgery, post-renal transplantation, and postoperative urinary diversion; (3) No coagulation abnormalities, no uncontrolled acute urinary infections or urinary tuberculosis; (4) American Society of Anesthesiology score grades I to II; (5) Preoperative ESWL treatment was not accepted; (6) Ureteral access sheath (UAS) could not be successfully placed and was excluded from the FUL group; (7) No excessive obesity or severe bone malformations. All patients were given antibiotics 30 minutes before surgery to prevent infections. All patients were operated by the same group of physicians, skilled in both types of surgery.

PCNL and FUL groups were compared in the fields of median body mass index (BMI) (31.5 vs. 29.3; P = 0.32), median age (45.10 vs. 36.58 years; P = 0.61), side of stone (P = 0.68), and median stone burden (15.5 vs. 14.2 mm; P = 0.18) (**Table 1**). Factors, including operation time, number and type of complications, blood loss, hospitalization time, economical cost, and stone-free rates, were judged by follow-up KUB imaging. They were retrospectively reviewed and compared.

Percutaneous nephrolithotomy technique

Briefly, PCNL group patients underwent general or spinal anesthesia or general anesthesia. Patients were placed in a semi-supine combined lithotomy position. The operation side leg was nearly fully extended with a slight abduction of the hip joint. The other leg was bent, allowing simultaneous reverse operation throughout the process (**Figure 1**). First, a 6/7.8 Fr Wolf rigid ureteroscope (Richard Wolf, Germany) was used to check the ureter to make sure the ureter was free of stones or strictures under the guidance of the guide wire (Boston Scientific). Next, the guidewire was placed into the renal pelvis and a 6 Fr open-ended ureteral stent was placed by ureteroscope directed through the guidewire. An artificial hydronephrosis was formed by injecting 0.9% sodium chloride into the renal pelvis through a ureteral stent to fill the renal collection system, to help puncture. A 16G coaxial needle was used to initially puncture into the dominant calyx under ultrasound guidance (BK Ultrasound System, Denmark).

The irrigation solution was discharged through the puncture needle tube, proving the puncture was successful. The guidewire was then passed through the needle sheath into the pelvic system. The next step was to use the dilated sheath sequentially from 10 Fr, 14 Fr, and 18 Fr to expand muscle and fascial layers. F16 outer sheath was used to place into the target calyx directed by the guidewire. Nephroscopy was performed with the nephroscope along the guidewire, using a peristaltic pump to continuously irrigate saline to keep the vision clear. The stone was disintegrated into fragments 2-3 mm using 550-μholium laser fibre (Lumenis GmbH, Germany) with an energy output of 1.5-2.0 J at 15-30 Hz. Under the influence of gravity and the irrigation fluid around the fragments, the stone fragments rapidly actively discharged out of the collecting system from the outer sheath. No stone fragments were detected by endoscopy and ultrasound. A 6 Fr double-J stent was placed anterogradely. If the anterogradely failed, we carried retrogradely when we punctured the lower calyx. Ureteroscopy was performed to confirm that the lower end of the double J tube was in the bladder. The operation was completed after 14/16 Fr renal fistula was placed optimally in the collecting system thought the PCNL channel and properly fixed.

The renal fistula was removed within 24-48 hours, as well as the urethral catheter within 48-72 hours after surgery after appropriate KUB films.

Flexible ureteroscopic lithotripsy technique

All operations were carried out under spinal anesthesia or general anesthesia. Patients were placed in the lithotomy position. All patients routinely used rigid ureteroscopy prior to flexible ureteroscopy to enlarge the ureter and put the thread into the renal pelvis. A 11/13 Fr (Cook, America) ureteral access sheath (UAS) was positioned as close to the renal pelvis as possible along the guidewire. Subsequently, a flexible bidirectional electronic ureteroscope (Olympus, Japan) passed through the UAS into the renal pelvis. If the stone was found, it was dusted into pieces < 2 mm using a 200 um holium laser fiber with the laser settings at 0.3 to 0.5 J and 15-40 H. A basket was used to move the stone to a favorable position for better gravel. If the stone was in an unfavorable position, most of the calculus was dusted *in situ*. Occasionally, some larger fragments were taken out using a Nitinol basket to do calculus analysis. A Fr6 double J ureteral stent was placed by rigid ureteroscopy if the stone was fragmented adequately. After 1 month, a follow-up visit was required. The ureteral stent was removed by cystoscope after appropriate KUB imaging.

Operation time of the PCNL group was from the start of puncture needle puncture to completion of renal fistula indwelling. Operation time of the FUL group was from the time when ureteroscope entered the urethra through ureteroscopy to the time when the double J tube indwelling was completed. The present study used KUB films to look for residual stone burden. After 1 month of surgery, KUB films were taken again to ensure that there were no urinary stones. The stone-free rate depended on the results which were gathered immediately after the operation and at one month. Asymptomatic status was evaluated at 3 months after the operation. Less than 3 mm asymptomatic stones are usually considered clinically insignificant residual fragments (CIRFs). Patients without stones or with CIRFs were considered successful cases.

Statistical analysis

SPSS 16.0 software was used for statistical analysis. Measurement data in accordance with normal distribution are expressed as mean and ± S.D. Independent samples t-test was

Table 2. Perioperative data of PCNL vs. FUL ($\overline{x}$ ± s)

	PCNL	FUL	*P* value
Operation time (min)	67.7 ± 20.42	107.8 ± 28.74	< 0.001
Hospitalization time (d)	6.84 ± 1.48	4.92 ± 0.68	< 0.001
Blood loss (g/L)	6.12 ± 3.94	0.65 ± 0.39	< 0.001
Complications (n)	7 (18.4)	2 (4.4)	< 0.001
Clavien Grade I	5	2	
Clavien Grade II	2	0	
Clavien Grade IIIa	0	0	
Clavien Grade IIIb	0	0	
Clavien Grade IVa	0	0	
Clavien Grade IVb	0	0	
Clavien Grade V	0	0	
Stone-free status (%)	93.8%	88.1%	0.07
CIRF	4 (10.8%)	9 (21.4%)	
Residual stone	2 (5.4%)	5 (11.9)	
Stone-free	31 (83.8)	28 (66.7)	
Economical cost (Yuan)	14605 ± 1754	20142 ± 2759	< 0.001

Note: CIRF, clinically insignificant residual fragments. a: severe sepsis, b: septic shock.

used to compare parameters between the two groups. The ratio of counting data was expressed by χ^2 test and Fisher's test. With P = 0.05 as the test level, the bilateral value of *P* < 0.05 indicates statistical significance.

Results

Intraoperative and postoperative parameters are shown in **Table 2**. All operations were successfully completed. A single channel was set up for lithotripsy in the PCNL group. Intraoperative endoscopy was successful in the FUL group, without infectious shock, ureteral perforation or avulsion, and other serious complications, intraoperatively and postoperatively. Mean operation times for PCNL and FUL groups were 62.3 ± 20.4 and 102.2 ± 24.39 minutes, respectively (P < 0.001). All PCNL operations were successfully performed through a single percutaneous tract. In 2 PCNL patients, failure to put forward DJ stent in the operation of lower calyx puncture was observed. They put the DJ stent in reverse. In the course of lithotripsy, part of the calculi was moved to the upper part of ureter, then percutaneous nephrolithotomy combined with rigid ureteroscopy was used to treat the stone under the body position.

Blood loss was calculated as the change in Hb concentrations of complete blood counts, preoperative and 24 hours after surgery. Postoperative hemoglobin drop was significantly lower in the FUL group, compared with the PCNL group (6.12 g/L vs. 0.65 g/L, P < 0.001). There was a significant difference between the groups in complications, according to the Clavien classification (P < 0.001). In the PCNL group, 2 cases received transfusions for continuous bleeding after surgery. The patients were discharged from the hospital through blood transfusion and sensitive anti-infection treatment. No patients received interventional embolization or nephrectomy. No patients in the FUL group received blood transfusions or interventional embolotherapy. PCNL and FUL groups, respectively, in 1 and 2 cases of postoperative fever (> 38.5°), were managed with appropriate antibiotics. Body temperatures gradually returned to normal. Final success rates were 88.1% in the FUL group and 93.8% in the PCNL group at first month follow-up (P = 0.07). In the FUL group, 5 patients had residual stones. There were 3 patients were lost to follow-up while two patients had no complaints about residual stones were followed. In the PCNL group, 2 patients had residual stones. One patient had no complaints or symptoms for residual stones and was followed up. One patient was lost to follow-up. Evaluation of the last patient was performed after the removal of the stent. This patient did not have any clinically significant residual fragments after evaluation by ultrasonography and KUB X-ray. The average cost in the PCNL group was ¥14605 yuan vs. FUL was ¥20142 yuan, respectively. Ureteroscope and its accessory equipment (such as stone basket and disposable soft mirror sheath) are costly and consumable. Therefore, the total cost of the FUL procedure was significantly higher than the PCNL group (P < 0.001).

Discussion

Under the influence of factors such as gravity, urine salt substances easily precipitate to stone formation in the kidneys, the calyx, and renal pelvis of small angle. These factors can cause renal calyx calculi that remain difficult to discharge by conservative therapy [8].

Currently, ESWL, FUL, and PCNL are the main minimally invasive methods used for the treatment of renal caliceal stones. ESWL has the advantages of less trauma, high patient tolerance, and fewer complications. PCNL surgery is mainly applicable to treat stones larger than 2 cm, while ESWL is commonly used in the treatment of stones smaller than 1 cm. However, due to the influence of factors such as stone size, quantity, composition, and patient size, renal pelvis and caliceal angle, lower caliceal and caliceal neck morphology, and stone clearance rates are relatively low. These are used in treating lower pole renal calculi < 2 cm and remain controversial [9-12].

With the rapid development of ureteroscope technology and related auxiliary lithotripsy equipment, the technology of ureteroscope has made great progress. Its adaptability has continuously expanded. The diameter of the flexible ureteroscope is only 2-3 mm and the endoscope is relatively soft. It can turn and bend at an angle of 180 degrees to 270 degrees. It displays advantages of minimal invasiveness, safety, enhanced recovery after surgery, and high gravel efficiency.

Both PCNL and FUL have the advantages of minimal invasiveness and rapid recovery. They are often used treat 10-20 mm renal calculi in clinical practice. Many clinical studies have confirmed that PCNL has a high rate of success in the treatment of caliceal calculi [13]. Some scholars have reported that PCNL has a high rate of success in the treatment of caliceal calculi with a diameter of 2-2.5 cm and a primary calculi clearance rate of 89%. PCNL needs to establish a surgical pathway through the renal parenchyma and risk of complications, such as postoperative infection, bleeding, colon injury, and pleural injury, remain relatively high. Armitage [14] reported that the unplanned readmission rate of patients within 30 days after PCNL surgery was 9.0%. In clinical practice, PCNL under the treatment of renal calyx calculi requires the building of an operation channel, by piercing the calyx due to channel and ureteral angle is too small. Once on the gravel into the ureter, to handle passively, prone to calculi residual or difficulties of double J tube indwelling. If ureteroscopy is forced, oscillation is likely to lead to kidney bleeding. In addition, PCNL has certain limitations. In cases of extreme obesity and severe spinal deformities, it cannot be completed.

Experts have suggested that the special structure of the renal calyx results in the low efficiency of FUL in treating lower pole stone. However, with the progress of technology and improvement in surgical instruments, the operation will not reduce calculi clearance rates in clinical application. It does not increase the incidence of complications, having been confirmed by many research institutes [15]. The 200 um holmium laser fiber has good curvature and easily accesses the lower renal calyx. FUL has gradually become an effective treatment method for renal caliceal calculi [16], with the following advantages [17]: (1) Surgical treatment through the natural cavity of the human body, avoiding renal parenchymal injury, and fewer complications; (2) Short hospitalization times and rapid recovery; and (3) FUL has obvious advantages for some special patients, such as obese patients. In this study, PCNL postoperative hospital stays were significantly longer than the FUL group. Postoperative early ambulation FUL helped the excluding of stones, with small trauma and fast recovery, which is in line with the prevailing rapid rehabilitation concept. In contrast, PCNL renal puncture needs established channels, collects required long-term postoperative renal fistula, and early to bed activities have increased the risk of postoperative bleeding. Postoperative recovery is relatively slow and hospitalization time is relatively long. In this study, patients in the FUL group spent significantly less time in hospital than those in the PCNL group. FUL treatment of renal calyceal calculi has the advantages of less trauma, lower incidence of complications, and faster recovery. Present results are consistent with previous results [18, 19].

Present research shows that FUL gravel efficiency is lower than PCN. There are disadvantages, such as long operative time, expensive surgical equipment, and long postoperative stone discharge times. In addition, the electronic ureteroscope is expensive and easily damaged, requiring special maintenance. Some studies have reported that the ureteroscope needs to be repaired every 10-20 times [20]. In protecting the ureteroscope, the fiber keeps sticking out of the mirror for 3-4 mm outside the body in the process of lithotripsy. When

Figure 2. The outer sheath is slanted downwards.

searching for stones, the holmium laser fiber should be returned to the mirror body for 2~3 mm, not damaging the mirror.

FUL group of patients will need fragmented stone into pieces < 2 mm, using a Nitinol basket to retrieve a few larger fragments [21, 22]. A high frequency and low-power laser lithotripsy way is usually adopted to crush into stone diameter < 2 mm. In addition, the experience of surgeons, proficiency of ureteroscope operation, and tacit cooperation of assistants influence operation times.

The present study found that the percutaneous approach had higher stone free rates, but the differences were statistically insignificant. The present study carried out percutaneous nephrolithotomy in semisupine-lithotomy position. It was found that the position was conducive to irrigant drainage and kept low intrarenal pressure (5-10 mmHg), although the procedure uses a peristaltic pump in the whole process even with high-pressure irrigation. Most of the fragments in PCNL burst out of the percutaneous renal puncture channel by the pressure of water flow or the position of the body. The improved irrigation process has a good visual effect and helps to remove fragments quickly by the sheath. This has increased the amount of stone removed and reduces the chance of bleeding due to excessive distortion of the tract. Additionally, an outer sheath allows passive removal of stone fragments in the process. Thus, it is not necessary to turn the stone powder into fragments with a diameter of less than 2 mm, which can shorten operation times.

All procedures were completed in 45° semisupine combined lithotomy position, compared to the conventional prone position. Advantages of this position are as follows. There is no need to change the position during the whole operation. It can provide a comfortable position for the patient, facilitate the intraoperative anesthesia monitoring, and can be simultaneously retrograde surgery as needed [23]. Since the outer sheath is slanted downwards (**Figure 2**), it can maintain low internal pressure of renal pelvis and flush out stone fragments quickly. Another advantage is that it provides a comfortable sitting position for the surgeon [24]. The ultrasound can avoid X-ray radiation damage to both patients and the operative team, reduce dependency on C-arm machines, and facilitate the work in primary hospitals. Three-dimensional localization using different sections may help avoid collateral damage [25].

Moreover, in the case of intraoperative inferior renal calyx puncture, the retrograde catheterization can be carried out through this position of the body if it is too difficult to place the catheter forward. In the process of lithotripsy, if the stone is moved to the upper ureteral segment, the lithotripsy can be carried out under the dual lens without changing the body position, improving the success rate of lithotripsy. However, FUL exhibited shorter postoperative hospital stays than the PCNL group and no differences concerning incidence of complications between the two groups were found. Patients with the extension of time did not affect the operation or postoperative recovery [26].

There are several aspects to note when performing percutaneous nephrolithotomy in semisupine-lithotomy position. The operation side should be fully extended, otherwise it will hinder the flexible operation of the calyx PCNL channel in the lower pole. The lower extremity of the opposite leg should be slightly extended, bending the hips and knees as much as possible. Otherwise, it will hinder the retrograde operation of the ureter. During intraoperative PCNL channel expansion, the kidneys of the affected side may be shifted inward, which can be appropriately pressurized by the assistant under the affected side costal arch. Additionally, the fascia expander rotates rapidly along the guidewire to overcome this problem.

Above all, on the premise of strictly choosing the operation indication, for 10-20 mm under the vast majority of renal calyx calculi, PCNL in semisupine-lithotomy position and FUL have reliable curative effects. The FUL group had preoperative indwelling DJ tube side ureteral dilatation. The surgery required a longer time than the PCNL group. However, regarding incidence of postoperative complications and postoperative hospital stays, it has obvious advantages. In addition, patients have higher acceptance of FUL. Thus, for 10-20 mm kidney stones, FUL is worthy of clinical application.

The present research is a retrospective study of a small sample. The sample size may have affected the reliability of conclusions, masking the statistical significance of significant differences. For instance, stone-free and postoperative complications. The standardization of surgical treatment is difficult and is often affected by many factors, such as equipment, technical conditions, patient willingness, and so forth.

Disclosure of conflict of interest

None.

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