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Outcomes of super-mini percutaneous nephrolithomy (SMP) and retrograde intrarenal surgery (RIRS) in the management of moderate size kidney stones

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Abstract

To evaluate and analyze the efficacy and safety of super-mini percutaneous nephrolithotomy (SMP) and retrograde intrarenal surgery (RIRS) in the management of moderate size renal calculi, we retrospectively collected and compared the date of 200 patients, who received either super-mini PCNL (n=100) or intrarenal retrograde surgery (n=100) at First Affiliated Hospital of Zhengzhou University between January 2016 and January 2019. The mean stone size was 17.86 ± 1.52 mm in the SMP group and 15.21 ± 1.68 mm in the RIRS group. The final stone-free rate (SFR) was significant in the SMP group as compared to RIRS group (97% vs 85% in the SMP and RIRS groups, p= 0.003). The operation time was comparable in both groups. The duration of hospitalization was 3.510 ± 1.480 days in the SMP group and 3.150 ± 1.044 days in the RIRS group (p = 0.048). The auxiliary rate was lower in SMP in contrast to RIRS group (10% vs 25%, p=0.005). Neither of the two procedures required blood transfusions. Complications between the SMP group and the RIRS group were not significantly different. We found out that SMP is more successful than RIRS with comparable complication rates, higher choice of treatment SFR and a lower auxiliary rate. Thus, SMP can be considered as a substitute for RIRS in the management of moderate size kidney stones.

Introduction

Renal stone is the most common disease in the field of urology and continues to rise worldwide across all ages. While its treatments also dramatically changed in the last few decades and tend to be more minimally invasive. The 2018 European association of urology (EAU) guideline on urolithiasis recommends extracorporeal shock wave lithotripsy(ESWL) or RIRS and percutaneous nephrolithomy (PCNL) as alternative option for stone size 10-20mm in renal pelvis or middle/upper calices of kidney, and for lower renal pole endourology (RIRS, PCNL) is as the primary treatment choice and ESWL as secondary option due to its lower SFR achievement [1]. PCNL is reported to have higher success rate with the cost of higher complications, which are associated with this procedure, including blood transfusion, bleeding, postoperative fever, septicemia, and damage to surrounding organs, meanwhile there is evidence emerging that morbidity decreases with the decreasing of the size of the PCNL access tract [2,3]. Keeping this in view, with the advancement in technologies and techniques various minimal and modified PCNL have engineered in the last two decades such as Miniperc, ultera-mini PCNL, mini-micro PCNL, micro PCNL and the latest modified design is Super-mini PCNL, which has improved metal access sheath 10-14 F [4]. RIRS is another alternative option for renal calculi, that is less invasive and safe but less effective, with the miniaturization of ureterorenoscopy, better vision, enhanced deflective capability and the use of ureteric access sheaths made it be used for a greater range of kidney stones [5,6]. There have been many studies that compared different modalities of PCNL with RIRS in the management of 10-20mm kidney calculi [7,8] but there is none to compare the newest PCNL design (SMP) with RIRS. In this retrospective study based at single center, we aimed to evaluate and analyze the efficacy and outcome of the SMP with RIRS in the management of moderate size kidney stones.

Materials and methods

We have collected and analyzed 200 patients retrospectively, who underwent Super-mini PCNL (n=100) or RIRS (n=100) procedures at the urology department of First Affiliated Hospital of Zhengzhou University in China between January 2016 to January 2019. Written consents were taken from all patients, who received the two procedures and were encompassed in this study. Expert surgeons performed all procedures. Male and female patients with age between 18 to 80 years and diagnosed by computed tomography (CT) with a single or multiple renal calculus between 10- and 20-mm size were included. Patients with transplant kidney, renal malformation or morphological anomalies (kidney with malrotation, horseshoe kidney, bifid pelvis and ectopic pelvic fusion) and pregnant at the time of surgery were excluded. The center has evaluated the physical condition of the patients by history taking, physical examination, urinalysis, urine culture, renal and liver function test, complete blood count, fasting blood glucose, coagulation tests and radiological examinations including ultrasonography, multi-slice spiral CT and kidney-ureter-bladder (KUB) radiography. A preoperative CT scan was utilized to measure stone size by maximum length. Sone-free rate (SFR) was evaluated by using plain radiography (KUB) and abdominal ultrasound on postoperative day one and non-contrast CT after one month of the surgery. The complications were classified in accordance with Dino-modified Clavien System [9,10]. The duration of surgery for SMP patients was counted from the start of renal puncture to withdrawal of percutaneous system from kidney. The demographics, size and site of stone, body mass index, degree of hydronephrosis, the duration of surgery, hospitalization time, SFR and complications were compared between the SMP group and the RIRS group.

Super-Mini PCNL (SMP)

General anesthesia was given to all patients for performing SMP procedures. At the start of the operation, a 5-F ureteric catheter was placed in the collecting system in the lithotomy position, and then the prone position was utilized. An 18-guage coaxial needle was inserted under fluoroscopy or ultrasound guidance to get percutaneous access, then 0,035 flexible tip guidewire, 12-14F metal dilator (the size depends on the stone burden) was used for dilation of the tract. Then a corresponding irrigation-suction sheath with an obturator was passed through the guidewire and placed into the punctured calyx. Then the metal connector was connected to the sheath after the removal of guidewire. The connector part of the irrigation sheath has an irrigation port and oblique tube, the irrigation port was attached to the irrigation pump and the oblique tube to specimen collection

bottle and then to the aspirator (negative pressure aspiration). The miniaturized endoscope (3.3 F working channel) was installed to the sheath via the rubber-cap. After the stone visualization either holmium laser (200-550μm) or a pneumatic lithotripter (0.8 mm probe) with continuing suction was used to perform lithotripsy. At the last step a single fluoroscopic image was taken for evaluation of stone-free size. Only in case of any inflammatory ureteric polyp due to stone obstruction, pelvic ureteric junction obstruction, significant residual stone, and concurrent lithotripsy of ipsilateral ureteric stone, a 5F or 6F JJ-stent was inserted. The indications for nephrostomy placement were significant bleeding or extravasation and residual stone, which required the second-look procedure. The detailed SMP procedure had been described by professor Guohua Zeng [4, 11].

Retrograde Intrarenal surgery techniques

General anesthesia was used for all those patients, who received RIRS procedure. Lithotomy position was utilized and a rigid ureteroscopy was insert into the bladder for visualization and to find out the location of ureter orifices followed by placing a "0.0889 mm" guidewire in the pelvis and then a ureter access sheath (UAS) 12-14 F is placed over the guidewire into the proximal ureter. The flexible ureterorenoscope (Olympus-P5 or Storz-X2) was passed within ureter access sheath into the renal pelvis then 200 μm Ho YAG laser was utilized for fragmenting renal stones. A nitinol basket was applied for the removal of stone fragments. At the end of the RIRS operation, 5-6 F the double J ureteral stent was used routinely.

Statistical Analysis

For statistical analysis, we used Statistical Package for the Social Sciences (SPSS) 20.0 program. We applied a T-test to compare normally distributed continuous variables. The Fisher's exact test or chi-squared test ($\chi 2$ test) applied to analyze the categorical variables between the two groups. The confidence interval was set at 95% and $p < 0.005$ was described as the statistical significance.

Results

All the patients in our study were 200, which were further divided into 100 patients in the SMP group and 100 patients in the RIRS group. **Table 1** illustrates the characteristics and demographic data of the two groups. There was no significant difference in age, sex, BMI, previous surgery, degree of hydronephrosis and preoperative creatinine between SMP and RIRS groups, and the stone size was bigger in SMP group as compared to RIRS group (17.68 ± 1.52 vs 15.21 ± 1.68, $p < 0.001$) and lower calyx calculi (39% vs 17%, p=0.0011) surgery was more frequently performed in the SMP group. The comparison of intraoperative factors and outcome of SMP and RIRS groups are shown in **Table 2**. Double J ureteral stent was used at the end of each RIRS operation, in SMP group 24% of patients had "DJ stents" for two weeks, nephrostomy tube was needed in 6% of patients. The mean duration of surgery was not different between the two groups (59.64 ± 17.212 vs 57.370 ± 17.594, p= 0.358). SMP group had a significantly higher initial stone-free rates after a first procedure as compare to the RIRIS group (88% versus 70%, p= 0.002). The number of patients found with residual fragments were 12 in SMP group and 30 in RIRS cohort. After going through the auxiliary procedures, which were much less in SMP cohort in contrast to RIRS (10% vs 25%, p= 0.005), the final stone-free rate was achieved significantly greater in SMP group as compared to RIRIS group (97% vs 85%, p= 0.003). The two groups SMP and RIRS didn't have significant overall complications (10 % vs 18%, p= 0.002). However, the hemoglobin drop was significant in the SMP group. There was mild hematuria in SMP and RIRS groups (4% vs 2%, p= 0.407) that last around 6 hours then settled spontaneously, and there was no need of blood transfusion for either of the two groups.

Discussion

For the last three decades, the main focus of urologists in urinary stone treatment is to achieve the highest stone-free rates with minimum complications. with the advancements in technology, modern flexible ureteroscopes are extensively used for small to moderate size calculi. In this milieu, tiny PCNL modalities such as mini PCNL, Micro PCNL, and Ultra-mini PCNL were introduced, which are the alternative choices in the management of moderate size renal calculi in addition to RIRS and ESWL procedures [12]. A global study by Clinical Research of the Endourology Society (CROES) has illustrated that the significant complications of PCNL were blood transfusion (5.7%), hydrothorax (1.8) and bleeding (7.8) [13, 14]. Meanwhile, a prospective study of 301 PCNLs by Kukreja et al. have revealed that bleeding is due to tract size, which is considered the only independent predictor of bleeding in the procedure

Table 1: The characteristics and demographic data of patients

Factor	SMP	RIRS	P-value
Patients	100	100	
Age	48.27 ±13.35	49.87 ±12.05	0.363
Gender			0.645
Male	71	68	
Female	29	32	
BMI	25.610 ±3.721	24.790 ±2.689	0.055
Comorbidities			
Hypertension	19	27	0.179
Diabetes	8	14	0.175
Previous Surgery			
URS	14	20	0.259
PNL	10	13	0.506
Stone Location			
Upper Calyx	21	27	0.321
Middle Calyx	26	23	0.622
Lower Calyx	39	17	0.0011
Pelvis	14	33	0.002
Stone Size (mm)	17.86 ±1.52	15.21 ±1.68	< 0.001
Degree of Hydronephrosis			0.289
Non or Mild	77	83	
Moderate/ Severe	23	17	
Positive Urine Culture	15	13	0.684
Preoperative Cr lever	76.20 ±28.20	78.99 ± 35.19	0.536

Table 2: The comparison of intraoperative factors and outcome of SMP and RIRS groups

Parameters	SMP	RIRS	P-value
Duration of surgery (min)	**59.640**±17.212	57.370±17.594	0.358
Hospital stay (days)	**3.510**±1.480	3.150±1.044	0.048
hemoglobin drop, g/L	**9.574**±7.160	4.980±10.045	0.00000
Postoperative Cr	**77.840**±28.200	78.880±24.302	0.780
JJ stent	**24**	**100**	**< 0.001**
Nephrostomy	**6**	**0**	
Initial SFR	**88**	**70**	**0.002**
Complication (overall)	**10**	**18**	**0.103**
Transfusion	0	0	
Fever	6	9	0.421
Renal Colic	3	6	0.306
Mild Hematuria	4	2	0.407
Urosepsis	1	3	0.312
Auxiliary Procedure rate (%)	**10**	**25**	**0.005**
Final Stone Free Rate (%)	**97**	**85**	**0.003**

[15]. To decrease complications and morbidity of PCNL that are caused by large tract size, a novel PNL-technique (SMP) was developed with an improved designed and smaller size nephroscope 7 Fr and a modified 10-14 Fr access sheath [4]. Ferakis and Stavropoulos found that mini-PCNL causes a lower risk of bleeding compared to the conventional procedure [16]. Zeng et al. in their study reported that SMP required no blood transfusion and had no significant postoperative complications [11]. In our study also no evidence of complications above the Clavien grade 2, and no blood transfusion was found in the SMP cohort, which is due to smaller tract size that lowered the risk of renal vasculature injury [17]. Thus, the renal vasculature system is less traumatized, which means less bleeding and better intra-operative visibility. Besides, the continuous irrigation system of SMP could effectively wash out the minor bleeding. The complications include fever and mild hematuria, which were comparable between SMP and RIRS

groups. The reduced risk of visceral trauma and bleeding are the benefit of RIRS over conventional PCNL, and the achieved 85% SFR we found is comparable to the previous studies i.e., 67% to 86.3% [18, 19, 20]. Few studies already have compared PCNL and RIRS procedures for treating moderate size renal stones, reporting that a better SFR is achieved at the cost of greater morbidity in the PCNL group [7,18,21]. Nevertheless, none of these studies have focused on SMP, and this current study has shown a higher stone-free rate (97%) with negligible complications.

In our study, the average operation time for SMP was 60 minutes, which is acceptable and comparable to other studies of SMP that have shown from 52 to 64 minutes [22, 23, 24]. We found that the duration of surgery was comparable between the SMP and RIRS groups. Even though, the study of Ozayar et al. reported that PCNL takes longer operation time than RIRS [25]. However, in the SMP technique, a continuous negative pressure system is used that actively removes the stone fragments, which doesn't require graspers or forceps to retrieve the fragments in most cases. Our study also has some limitations such as: It's a retrospective nature, being a single-center study, the short follow up time, and the sample size was relatively small. We believe that prospective studies for such variables with a significantly number of patients will have a stronger and better evaluation of these phenomena.

Conclusions

Based on our study, SMP can be an alternative modality to RIRS for the management of moderate size kidney stones as it has higher stone clearance rates as compared to RIRS and comparable complication with lower auxiliary rates.

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Conflict of Interest

The authors declare no conflict of interest.

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