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Original Research Article

Outcome Assessment of Tubeless Mini- Percutaneous Nephrolithotomy (PCNL) for the Treatment of Large (>20 MM) Renal Stones

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Abstract

Aim: The aim of this study was to evaluate the outcomes of tubeless mini- percutaneous nephrolithotomy (PCNL) for the treatment of large (>20 mm) renal stones.

Methods: The study included consecutive adult patients who underwent mini-PCNL for large (>20 mm) renal stones for the period of 2 years at Sri venkateshwar institute of medical sciences, Tirupati, India. Preoperative, operative, postoperative, and follow-up data during outpatients' visits were prospectively recorded and maintained using a computer database. The data were retrospectively analyzed. The study included 200 patients in the study.

Results: The study included 200 patients with mean age 42.9 ± 13.8 years (range 18–79) and mean stone size 30.2 ± 9.6 mm (range 20–70). Mean operative time was 61.8 ± 30.1 min (range 25–180). The average number of tracts per renal unit was 1.26. The stone-free rate following the single-session of mini-PCNL was 86% (n = 172). Mean hospital stay was 2.9 ± 0.9 days.

The overall intraoperative and 30-day postoperative complication rate was 8% (n = 16), with the majority being Clavien classification Grades I and II (n = 15). Minor Grade (I–II) complications included postoperative fever requiring antibiotics in cases, postoperative haematuria requiring blood transfusion in two cases, severe postoperative pain requiring prolonged opioid analgesia in two cases, and perinephric hematoma that was managed conservatively in two cases.

Conclusion: Mini-PCNL is a safe and effective treatment for the management of adult patients with large renal stones. Stones located in multiple sites inside the PCS is the only predictor of unsuccessful outcome.

Keywords: Mini-PCNL, RIRS, Stone.

Introduction

Urolithiasis is a common disease and is considered a relevant public health problem worldwide. [1] Although kidney stones initially often remain asymptomatic, treatment is commonly performed to prevent future complications associated with the disease (e.g., renal colic, urinary tract infections, and impairment of kidney function). [2] The surgical treatment of kidney stones is complex because multiple competitive treatment modalities are available and more than one modality may be appropriate in some cases. The selection of proper treatment, which is directed by patient‐ and stone‐specific factors, remains the most significant predictor of successful outcomes. The treatment for kidney stones should achieve both high stone‐free rates (SFRs) and low complication rates.

Extracorporeal shock wave lithotripsy (ESWL) and flexible ureterorenoscopy (URS) are the common treatment options for kidney stones of <20 mm in diameter. [3] The American Urological Association Guidelines recommend percutaneous nephrolithotomy (PCNL) as the first‐line treatment for patients with a large renal stone (>20 mm) [4] because it has a higher SFR than SWL or URS and is less invasive than open surgery or laparoscopic/robotic‐assisted procedures. [5]

Nephrolithiasis is a common worldwide disease with a rising incidence in the last few decades. [6] Current practice based on international guidelines, suggest percutaneous nephrolithotomy (PCNL) as the primary treatment for renal stones >20 mm, which is performed via 24–30F percutaneous renal dilatation. [2,4] Although this technique offers excellent stone‐free rates, it has a relatively high incidence of complications with a systematic review by Seitz et al. in 2012 of 11,929 patients demonstrating an overall complication rate of 23.3%. [7] Recent evidence, including a systematic review, has identified that tract size is the main factor affecting blood loss during PCNL. [8,9]

In an attempt to reduce the morbidity, miniaturization of renal access size in PCNL was first introduced by Helal et al. in 1997. [10] Over the next two decades, several techniques of miniaturized PCNL (mini‐Perc, mini‐PCNL, or minimally invasive PCNL) have been described using 14–20F percutaneous renal dilatation with the primary goal to achieve high stone‐free rates with the reduction in procedure‐related complications. More recently, even smaller renal access systems have been described, including ultra‐mini PCNL with 11–13F sheath, super‐mini PCNL with 10–14F sheath, mini‐micro PCNL with 8F sheath and micro‐PCNL with <5F sheath. [11] Evidence for the superiority of any individual technique is poor with heterogeneous outcomes.

The aim of this study was to evaluate the outcomes of tubeless mini-percutaneous nephrolithotomy (PCNL) for the treatment of large (>20 mm) renal stones.

Materials and Methods

The study included consecutive adult patients who underwent mini‐PCNL for large (>20 mm) renal stones for the period of 2 years at Sri venkateshwar institute of medical sciences, Tirupati, India. Preoperative, operative, postoperative, and follow‐up data during outpatients' visits were prospectively recorded and maintained using a computer database. The data were retrospectively analyzed. The study included 200 patients in the study. Exclusion criteria were concomitant ipsilateral obstructing ureteric calculi. Stone size was defined as the largest dimension of a single stone or the sum of the largest dimensions of multiple stones.

Variables included were age, sex, stone location, history of urolithiasis, Guy's stone score, [12] stone size, percutaneous tract location and numbers, perioperative hemoglobin change, hospital stay, stone-free status, and 30-day complications. Noncontrast computed tomography (NCCT) was the preoperative diagnostic modality for all patients. All procedures adhered to the ethical guidelines of Declaration of Helsinki and its amendments. All patients included in the study provided a consent for undergoing the procedure. The authors confirm the availability of, and access to, all original data reported in this study.

Surgical technique

All procedures were carried out under spinal anesthesia by a single surgeon (SK) at a tertiary care hospital. In the lithotomy position, a 6F ureteric catheter was secured at the level of the ipsilateral pelvi-ureteric junction. The patient was then turned to the prone position and secured on the operating table with padding of the chest and pelvis and pressure points. Prepping and draping were done, so the tip of the ureteric catheter was accessible in the sterile field. A fluoroscopic guided renal puncture was performed using 2 planes (0°C and 30°C-arm rotation) after retrograde pyelography to enable access to the desired calyx.

The preferred percutaneous entry point of the operating surgeon was a supra 12th rib approach with an interpolar renal puncture to allow accessibility to almost all the pelvic-calyceal system (PCS) through a single tract providing there was at least mild hydronephrosis. A 0.035-inch Zebra Guidewire (Boston Scientific, USA) was passed to the PCS and either secured down the ureter or coiled in a renal calyx. The needle was removed, and either a single-step or serial dilatation was performed using fascial dilators with the eventual placement of a 16, 18, or 20F peel-away renal access sheath.

The 12F mini-nephroscope (MIP, Karl Storz Endoskope, Tuttlingen, Germany) was connected to an intermittent flow irrigation system, which enabled high flow irrigation for <3 s followed by a subsequent 2 s pause. A pneumatic ballistic lithotripter with a 1.2 F probe was used to disintegrate the stones. Fragment evacuation was achieved by a combination of the vacuum cleaner effect and saline flushing through the retrograde ureteral catheter. Tri-radiate grasper was rarely used to remove persistent stone fragments. At the end of the procedure, the ureteric catheter was removed, and an antegrade double-J stent was placed. No nephrostomy tubes were placed even in patients who required multiple tracts. Operative time was calculated from the insertion of the ureteric catheter till ureteric stent insertion.

Complications were recorded and classified according to the modified Clavien-Dindo classification. [13] Stone-free status was evaluated with X-ray kidney-ureter-bladder for radiopaque stones and NCCT for radiolucent stones within 2 weeks after PCNL. Patients were declared stone-free if they had complete clearance or an insignificant residual renal fragment <4 mm. Stent removal was performed under topical anesthesia 2–4 weeks after the procedure if no significant residual fragments were seen.

Statistical analysis

The data were stored and analyzed using SPSS (v20) software (IBM SPSS Statistics, Armonk, NY, USA). Univariate analysis (Chi-square or t-test) was used to compare the variables between stone-free patients and those with significant residual fragments. Multivariate logistic regression analysis was used to define independent risk factors. $P < 0.05$ was considered to indicate statistical significance.

Results

Table 1: Operative data and postoperative outcomes of mini‑percutaneous nephrolithotomy for large renal stones

Variables	n (%)
Number of percutaneous tracts	
One	160 (80)
Two	30 (15)
Three	8 (4)
Four	2 (1)
Location of percutaneous tracts	
Upper calyx	16 (8)
Mid calyx	110 (55)
Lower calyx	40 (20)
Multi‑calyceal	34 (17)
Stone‑free status	172 (86)
Complications	16 (8)
Grades I‑II	15 (7.5)
Grade III	2 (1)
Blood transfusion	3 (1.5)

The study included 200 patients with mean age 42.9 ± 13.8 years (range 18–79) and mean stone size 30.2 ± 9.6 mm (range 20–70). Mean operative time was 61.8 ± 30.1 min (range 25–180). The average number of tracts per renal unit was 1.26. The stone‑free rate following the single‑session of mini‑PCNL was 86% (n = 172). Mean hospital stay was 2.9 ± 0.9 days.

The overall intraoperative and 30‑day postoperative complication rate was 8% (n = 16), with the majority being Clavien classification Grades I and II (n = 15). Minor Grade (I–II) complications included postoperative fever requiring antibiotics in cases, postoperative haematuria requiring blood transfusion in two cases, severe postoperative pain requiring prolonged opioid analgesia in two cases, and perinephric hematoma that was managed conservatively in two cases. Grade III complications were observed in only 1% (n = 2) as one patient required renal angioembolization for severe hematuria 7 days following the procedure. The other patient had pleural effusion following upper calyx puncture requiring an intercostal chest drain. Both patients recovered well following the intervention and were discharged with no further procedures required. Blood transfusion was needed in 3 patients (1.3%). The average hemoglobin decrease was 1.3 g/dL (range 0–3.9). No patients had life‑threatening complications (Grade IV) or death (Grade V).

Table 2: Univariate analysis of factors affecting stone‑free status for mini‑percutaneous nephrolithotomy of large renal stones

Categorical variables	Total (n=200)	Stone free (n=172; 86), n (%)	P
Gender			
Male	50	45	0.264
Female	150	127	
Previous stone treatment			
No	140	132	0.202
Yes	60	40	

Laterality			
Left	110	85	0.580
Right	120	87	
Stone size (mm)			
20-40 mm	170	147	0.050
>40 mm	30	25	
Stone location			
Renal pelvis	50	50	0.003
Single calyx	20	15	
Multiple sites	130	107	
Staghorn stones			
No	145	140	0.006
Yes	55	32	
Guy's stone score			
1	40	40	0.020
2	100	85	
3	30	22	
4	30	25	

On multivariate analysis, independent risk factor for significant residual stones was the presence of the stones in multiple sites inside the PCS (relative risk: 13.44, 95% confidence interval: 1.78–101.43, P = 0.012).

Discussion

The renal stone has upgrading role in the morbidity and quality of life of patients and its prevalence is about 10%. [14] Also, the recurrence of renal stones may be up to 50%. [15] The impact of recent technology on the kidney stone management has a great role, especially the advancement of minimally invasive technique such as extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), retrograde intra renal surgery (RIRS). [16]

The surgical technique of mini‐PCNL in this study has been adapted from the Chinese method described by Li et al. of Guangzhou Medical College in China. [17] They reported a stone‐free rate of 89% in their retrospective series, which contained 4760 mini‐PCNLs. This is slightly more than the 86% stone‐free rate in the present study, but they reported their experience with all stone sizes while we reported only for large stones.

Zeng et al. published the largest series of mini‐PCNL outcomes of 13,984 cases. [18] This retrospective series analyzed 7234 complex stones. They reported an average of 1.25 tract per renal unit, with 79.3% single tract procedures. In the present study, similar results were observed (1.26 average number of tracts with 80% performed through a single tract). Another advantage of mini‐PCNL in the treatment of large renal stones is the ability to access most of the PCS through one tract, as shown in this study and Zeng et al. study. [18] The reason for the use of a single tract in 76% of cases in this study is attributed to the preference of accessing the PCS through the middle calyx. This interpolar renal access enabled accessibility to almost all the PCS and therefore allowing complete stone clearance without the need for multiple tracts in the majority of cases. [19] Recently, Lahme published outcomes of mini‐PCNL for larger stones >5 cm2 in 321 patients and reported a stone‐free rate of 94.7%. [20] However, this was achieved after a retreatment rate of 38.7%.

The main advantage of mini‑PCNL is lesser bleeding‑related complications compared with standard PCNL. In a systematic review, complications of standard PCNL included blood transfusion in 7% of cases and an average hemoglobin drop of 2.3 g/dL. In the present study, these bleeding complications were decreased as blood transfusion was needed in 1.5%, and the average hemoglobin drop was 1.3 g/dL. Moreover, lower overall and Clavien‑Dindo grade III‑V complication rates were observed in this study compared with that of the standard PCNL from Seitz's review (Grade III: 8.4% vs. 23.3% and Grade IV: 0.9% vs. 4.74% respectively). [7] A randomized controlled trial by Cheng et al. in 2010 found that blood loss and the need for blood transfusion was significantly lower in mini ‑PCNL using a 16F sheath compared to standard 24F PCNL ($P < 0.05$). [21,22]

Another advantage of mini‑PCNL is omitting the need for nephrostomy tube placement after the procedure in most cases. A meta‑analysis comparing tubeless versus standard PCNL procedures reported that tubeless procedures led to shorter hospital stay, less postoperative pain, and possibly quicker recovery. [23] The mean hospital stay in this study was 2.9 days because all patients were admitted 1 day prior to surgery and stayed for one or 2 days after the procedure as per hospital policy. When looking for risk factors for residual stones in this study, the presence of stones in multiple sites inside the PCS was the only independent predictor in multivariate analysis. Of note, neither Guy's classification for stone burden nor the presence of staghorn stones was a significant risk factor in predicting residual stones in multivariate analysis. The stone size was not significant in univariate analysis. This indicated the versatility of mini‑PCNL for the treatment of various stone burdens.

Conclusion

Mini‑PCNL is a safe and effective treatment for the management of adult patients with large renal stones. Stones located in multiple sites inside the PCS is the only predictor of unsuccessful outcome.

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