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Article

Safety and Efficacy of Bilateral Tubeless Supine Mini-Percutaneous Nephrolithotomy for the Management of Bilateral Renal Calculi in Renal Failure Patients

Puvai Murugan Ponnuswamy *, Bhalaguru Iyyan Arumugam, Shree Vishnu Siddarth Rajagopal and Krishna Mohan Boopathy Vijayaraghavan

Department of Urology, PSG Institute of Medical Sciences and Research, Coimbatore 641004, India; drbhalaguru@yahoo.com (B.I.A.); vishnusiddarth123@gmail.com (S.V.S.R.)
* Correspondence: puvai@yahoo.com; Tel.: +91-9042272272

Abstract: Background: To evaluate the safety, efficacy, feasibility, stone-free rate, and complications of bilateral tubeless supine mini-percutaneous nephrolithotomy (M-PCNL) for bilateral multiple renal calculi with renal failure as a single-stage procedure. **Materials and Methods:** We conducted a retrospective study from January 2020 to March 2022 in adult patients with bilateral renal or proximal ureteric calculi with renal failure who were subjected to bilateral supine tubeless M-PCNL. Patients on regular hemodialysis before the procedure were excluded. Data regarding the demographic profile, stone characteristics on non-contrast computed tomography (NCCT), duration of surgery, complications, and auxiliary procedures were retrieved from clinical records. Residual stone fragments of≤4mm in NCCT were considered clinically insignificant. The Clinical Research Office of the Endourological Society validation ofClavien score for PCNL complications was used. **Results:** A total of twenty-seven patients with a mean age of 45.9years were included in this study. The mean size of stone diameter per renal unit was 2.4 ± 0.4 cm. The mean preoperative serum creatinine was 2.8 mg/dL. A total of 62 tracts and 27 sessions were required for complete treatment of all 54 renal units in the 27 successfully treated patients. The average operating time was 75 (52–122) min on both sides. Serum creatinine drop at onemonth postsurgery was statistically significant ($p < 0.0001$). Mean hospitalization time was 3.6 days [3–6 days]. The primary stone-free rate was 92.5%. Grade I, II, and IVA complications were recorded in three (11.1%), eight (29.6%), and two (7.4%) patients, respectively. **Conclusion:** Bilateral tubeless supine M-PCNL for bilateral renal calculi in selective patients with renal failure in a single session is a safe, feasible, and effective option which can be carried out without increased morbidity and can be attempted if the first-side M-PCNL has gone smoothly within a reasonable amount of time.

Keywords: supine percutaneous nephrolithotomy; mini percutaneous nephrolithotomy; tubeless percutaneous nephrolithotomy; renal failure; bilateral renal calculus; obstructive uropathy

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1. Background

Urolithiasis is a common disease in urological practice with a high socio-economic impact. Some 10% to 12% of the world population have urolithiasis [1], and 12% to 26% of them have bilateral nephrolithiasis [2]. Obstructive uropathy due to bilateral nephrolithiasis is one of the causes of acute kidney injury (AKI), accounting for 10–12% of obstructive AKI cases [3]. It is a urological emergency needing immediate intervention. Intervention can be multi-staged, with diversion of the system in the first stage followed by definitive treatment of stones in later stages once AKI resolves. Single-stage procedures like bilateral prone percutaneous nephrolithotomy (PCNL) have been attempted in this subset of patients, with good outcomes [4,5]. But prone PCNL requires general anesthesia and change of position during the procedure, resulting in prolonged operative time and increased perioperative morbidity in this subset of patients. The advantage of supine PCNL is that it can be

achieved under spinal anesthesia and requires a minimal change of position. Simultaneous ureteroscopy can be performed during PCNL. Furthermore, by reducing the tract size of nephrostomy from standard PCNL (24–26FR) to mini PCNL (20FR), the risk of bleeding, post-operative pain, and analgesic requirements can be reduced [6,7]. However, to our knowledge, there are only a few studies regarding the safety and feasibility of bilateral supine mini PCNL (M-PCNL) in this subset of patients.

Hence, we evaluated the safety, efficacy, feasibility, stone-free rate, and complications of bilateral tubeless supine M-PCNL for bilateral renal calculi with renal failure as a single-stage procedure.

2. Material and Methods

This is a retrospective observational study conducted in our hospital, in the Department of Urology, between January 2020 and March 2022. Institutional ethical committee clearance was obtained for the study (Institutional Human Ethics Committee, PSG Institute of Medical Sciences and Research, approval number: 22/019). Data were collected from clinical records of all the patients with renal failure (serum creatinine > 1.4 mg/dL) who underwent bilateral supine mini-percutaneous nephrolithotomy (M-PCNL) within the designated time period. Patients on regular hemodialysis before the procedure were excluded. As this was a retrospective study with analysis of clinical record data, informed consent was not obtained from individual patients.

Demographic profile, detailed medical history, physical examination, hematological and biochemical investigations, and stone characteristics on non-contrast computed tomography (NCCT) were retrieved from pre-operative evaluation records. Operative time was calculated from the time of cystoscope insertion to the completion of the skin suture on the second side. The complications were graded according to the Clinical Research Office of the Endourological Society validation of Clavien score for PCNL complications [8]. Residual stone fragments of $\leq$4 mm in post-operative NCCT were considered clinically insignificant.

2.1. Supine Mini-PCNL Technique

Supine tubeless mini-PCNL was carried out under spinal anesthesia. Initially, in the lithotomy position, cystoscopy was performed and a 5 Fr ureteric catheter was deployed into both renal systems under a C-arm intensifier. The patient was then positioned in a modified Valdivia position (Iyyan position), as shown in Figure 1A,B. The more symptomatic side was operated on first. The patient was placed with the first operative side at the edge of the table, with a small jelly bolster under the flank to obtain a mild rotation of about 10–15 degrees. The ipsilateral arm was adequately protected and left lying over the thorax. The ipsilateral leg was kept straight and the contralateral leg flexed and abducted at the hip, and flexed at the knee. The pelvicalyceal system (PCS) was opacified by injecting non-ionic water-soluble contrast (Iohexol) and the desired calyx was selected for the initial puncture. Using an 18 G needle, the puncture was carried out under fluoroscopic guidance using the triangulation technique. A 0.032 hydrophilic guide wire was introduced into the PCS and gradually deployed into the ureter. Tract dilatation was carried out with 18Fr using a single-step Teflon dilator, and then a 20 Fr Amplatz sheath with an 18 Fr mini nephroscope was introduced into the renal system. Using a pneumatic lithoclast, stones were fragmented. The large fragments were expelled by the Bernoulli phenomenon with intermittent removals of the nephroscope from the outer sheath. Using fluoroscopy and nephroscopy, stone clearance was assessed. If there were stones seen on fluoroscopy, but they could not be assessed by the current puncture, a second puncture was made under fluoroscopic guidance after plugging the first puncture's Amplatz sheath with a needle cap. The second puncture was made in such a way that access to the remaining stones was easy (Figure 1C). Sometimes a third puncture was needed when there were multiple stones in difficult locations, such as stones in calyceal diverticulum. Then, 5Fr 26 cm double J stents were deployed in antegrade fashion into the renal system after complete clearance. All patients received 20 mL of 0.25% Ropivacaine with 0.5 µg/kg bodyweight Dexmedetomi-

dine for tract block. Nephrostomy tract infiltration was carried out by inserting a 23-gauge spinal needle up to the renal capsule under fluoroscopy guidance along the Amplatz sheath at 6 and 12 o′clock positions. The Amplatz sheath was removed under vision and the PCN tract closed using 3-0′non-absorbable monofilament sutures. The Amplatz sheath was removed once there was no active bleeding in the PCS. No nephrostomy tube was deployed into the renal system. The compressive dressing was applied at the surgical site (Figure 1D). A similar procedure was performed on the opposite side once there was no active hemorrhage in the ipsilateral side; and was completed within a reasonable amount of time.

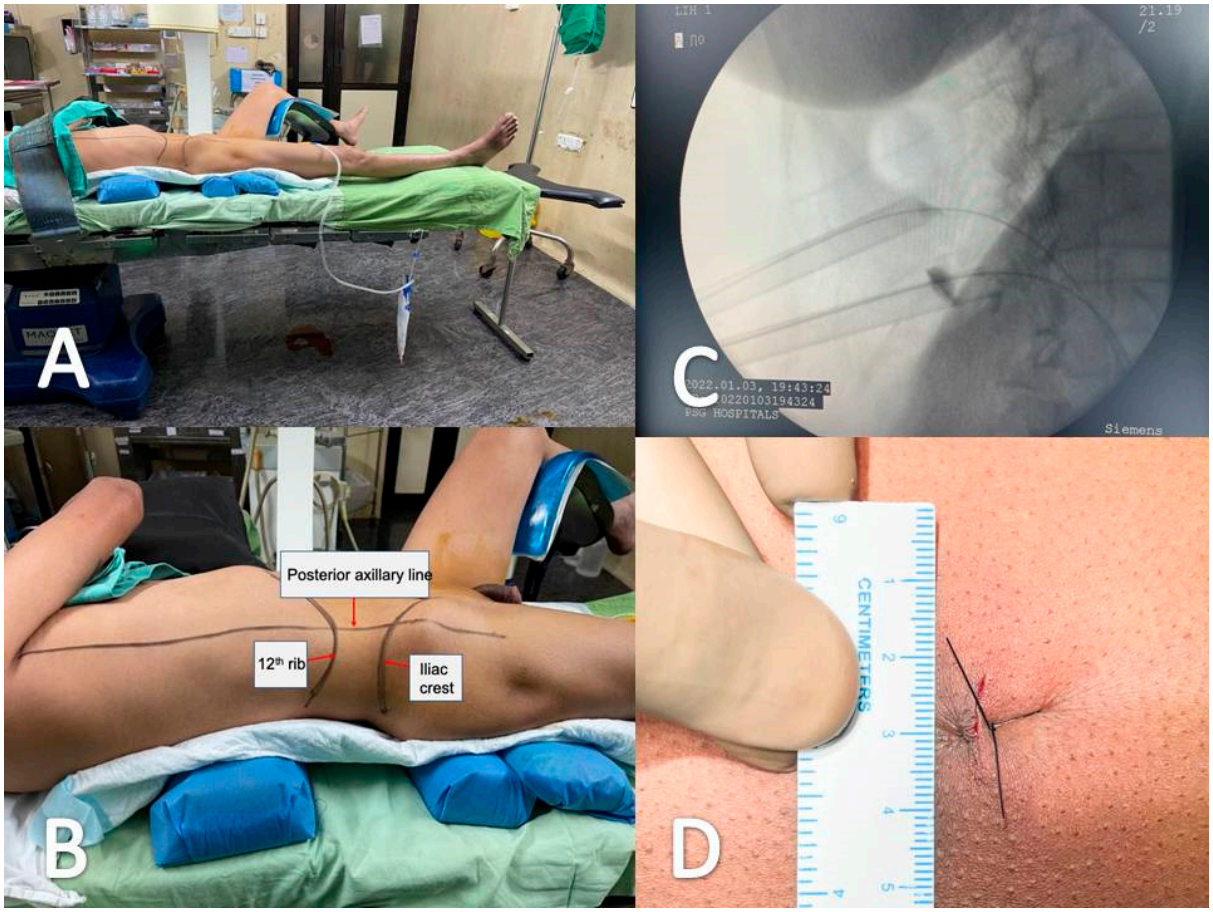

Figure 1. Supine mini-PCNL. (**A**): Modified Valdivia/ Iyyan's position; (**B**): Surface marking for supine M-PCNL; (**C**): Fluoroscopic image of multiple tracts in a single kidney; (**D**): Sutured wound size.

2.2. Statistical Analysis

Descriptive data were presented in the form of mean, range, percentage and standard deviation. Statistical analysis was completed using SPSS software, version 21.0 (IBM Corp., Armonk, NY, USA). Statistical significance was kept below 0.05. The confidence interval was set at 95%. The univariate analysis included a *t*-test and ANOVA test for quantitative variables, and a chi-square test for qualitative variables.

3. Results

A total of 35 renal failure patients underwent bilateral tubeless supine mini-PCNL (M-PCNL) under spinal anesthesia between January 2020 and March 2022. The indication for bilateral tubeless supine M-PCNL was bilateral renal or upper ureteric calculus with a component of acute kidney injury. Eight patients were excluded from the study as they were on regular dialysis before the procedure. Table 1 shows the preoperative profile of

the patients. The mean age of the patients was 45.9 (range 27–66) years. Four patients were above the age of 60. The mean BMI was 24.5 ± 2.8 kg/m^2. Among 54 pelvicalyceal systems, stones were located in the renal pelvis (n = 51), lower calyx (n = 41), the middle calyx (n = 13), proximal ureter (n = 6), and the upper calyx (n = 4). Some 46 renal units had a lower calyceal puncture, 10 renal units had a middle calyceal puncture, and 4renal units had an upper calyceal puncture. Six renal units required two punctures for good stone clearance. All the stones were fragmented using a pneumatic lithoclast. The mean stone size was 2.4 ± 0.8 cm in each renal system. The mean operative time was 75 min (52–122 min) for both sides. All patients had bilateral 5Fr 26 cm DJ stenting with no nephrostomy deployed.

Table 1. Patient profile.

Total patients	27
Mean age (years)	45.9
Male–female ratio	16:11
Mean stone size (cm)	2.4 ± 0.4
Body mass index (kg/m^2)	24.5 ± 2.8
Comorbidities	
Diabetes mellitus	16
Systemic hypertension	9
Heart disease	6
COPD	8

COPD: chronic obstructive pulmonary disease.

Operative outcomes are tabulated in Table 2. Four patients had significant hematuria and a significant drop in hemoglobin and were advised complete bed rest, parenteral antibiotics, and analgesic and intravenous fluid administration. All four patients had packed red cell transfusion; among them, three had a lower calyceal puncture, and one had an upper calyceal puncture. None had to undergo post-operative renal angioembolization for hematuria. The mean drop in hemoglobin was 1.28 ± 0.77 gms% (Table 3). The mean drop in hemoglobin was significantly higher in patients whose operative time was more than 90 min (2.5 ± 0.75 gms%).

Table 2. Operative outcomes.

Mean operative time	75 min
Mean hospitalization time in days	3.7 days
Access	
Single	46
Multiple	6
Auxiliary procedures	2
Stone clearance rate	92.5%
Post-operative complications based on CROES validation of Clavien scores n (%)	
Grade 1	3 (11.1)
Grade 2	8 (29.6)
Grade 4 A	2 (7.4)

Table 3. Post-operative bleeding.

Hemoglobin [Hb] Status	
Mean pre-operative Hb % (mean ± SD)	11.95 ± 1.2
Mean post-operative Hb % (mean ± SD)	10.67 ± 1.5
Mean drop in post-operative Hb % (mean ± SD)	1.28 ± 0.77
Packed red cell transfusion rate (*n*)	4
Mean drop in post-operative Hb % (mean ± SD) if operative time < 90 min	2.5 ± 0.75
Mean drop in post-operative Hb % (mean ± SD) if operative time > 90 min	1.06 ± 0.55
p value < 0.001	

The mean preoperative serum creatinine level was 2.78 ± 0.56 mg/dL, immediate post-operative and one month post-operative levels were 3.19 ± 0.89 and 1.70 ± 0.41 mg/dL, respectively (Table 4). The immediate rise in serum creatinine and the fall in serum creatinine at one month post-operatively were statistically significant when compared to baseline values (p value < 0.001). Two patients needed transient post-operative hemodialysis and four had a urinary tract infection for which they were administered appropriate sensitive parenteral antibiotics. Residual fragments were detected in 2 patients, and the remaining 25 patients (92.5%) had complete stone clearance. The average post-operative hospital stay was 3.6 days (range, 3–6). Two patients with residual fragments had either M-PCNL or flexible ureteroscopy and stone basketing during DJ stent removal. All 27 patients were stone-free at the end of 3 months.

Table 4. Variation in serum creatinine levels (pre-op vs. post-op).

Mean serum creatinine (n = 27)	Baseline (mean ± SD)	2.78 ± 0.57
	Immediately post operative (mean ± SD)	3.20 ± 0.89
	At 1 month post operative (mean ± SD)	1.70 ± 0.41
Mean serum creatinine of patients requiring transient dialysis in post-operative period (n = 2)	Baseline (mean ± SD)	3.40 ± 0.28
	Immediately post-operative (mean ± SD)	5.60 ± 0.28
	At 1 month post-operative (mean ± SD)	1.9 ± 0.30

4. Discussion

Percutaneous nephrolithotomy (PCNL) and its variations have emerged as the treatment of choice for renal stones larger than 2 cm. The technique of PCNL has evolved over time since the first extraction of stones by the percutaneous approach by Fernstrom and Johansson in 1976 [9]. Valdivia et al. first reported supine PCNL in 1987, and it was popularized in 1998 by the same authors. Supine PCNL reduced the operative time and need for general anesthesia. The M-PCNL technique was first developed and accomplished by Jackman et al. in the pediatric population with the use of an 11 F access tract [6]. Reducing the caliber of the access sheath decreases the damage to the renal parenchyma and hence reduces the risk of hemorrhage and urinary leak [10]. Ferakis N et al. in their review concluded that mini-PCNL seems to be a reasonable alternative for patients with a small-to-medium-sized stones, especially when a tubeless procedure is considered [11]. Tubeless PCNL is safe and effective and has significantly less morbidity, a shorter hospital stay, and a lesser post-operative analgesic requirement in comparison with standard PCNL [10]. Traxer et al. reported that patients treated with tubeless PCNL required significantly less analgesia compared with standard and mini-PCNL patients and were associated with decreased morbidity and low cost [12]. Aghamies et al. concluded that tubeless PCNL is feasible and more advantageous than standard PCNL for uncomplicated multiple renal calculi [13]. Bellman et al. first reported tubeless PCNL in 112 patients and compared it with standard PCNL; they later concluded that tubeless PCNL has less post-operative discomfort, short

hospitalization, and speedy recovery [14]. Song et al. showed that recovery time was significantly shorter for patients receiving tubeless mini-percutaneous nephrolithotomy than those treated with standard PCNL in pre-school children with renal calculi [15].

Tubeless simultaneous bilateral prone percutaneous nephrolithotomy was performed by Pillai et al. in 85 patients with an average age of 45.7 years. The success rate was 95.2% and the mean drop in hemoglobin was 1.10 gm per patient. The mean hospitalization time was 69.6 h. Complications including urosepsis, renal damage that leads to hemodialysis, pneumonia, and hydrothorax were less frequent [4]. Jones et al. in their systematic review observed that the initial stone-free rate and final stone-free rate after bilateral PCNL were 72.6% and 92.4%, respectively, with a mean operative time of 171.1 min; the mean duration of hospital stay was 3.9 days [5]. In our study, the initial stone-free rate was 92.5%, the mean operative time was 75 min, the mean duration of hospital stay was 3.7 days, and the fall in hemoglobin was 1.28 g/dL.

Risk factors for renal bleeding during percutaneous renal surgeries include upper calyceal puncture, large stones, multiple stones, multiple tracts, longer operative time, an inexperienced surgeon, and having a solitary kidney [16]. Renal puncture in the supine position requires that the needle pass horizontally, where an upper calyceal puncture will hit the calyceal neck and not the infundibulum, meaning less chance of infundibular vessel injury and pseudo-aneurysm. In our study, the drop in hemoglobin post-operatively was significantly higher when the operative time was more than 90 min.

Seitz C et al. in their review showed that Clavien–Dindo classification of post operative complications can be effectively used in PCNL [17]. In patients undergoing PCNL, they reported Clavien I complications in 11.4% (range 4–37%), Clavien II complication in 7.1% (range 4.5–17.6%), Clavien IIIa in 2.7% (range 0–6.6%), Clavien IIIb in 1.4% (range 0–2.8%), Clavien IVa in 0.4% (range 0–1.1%), Clavien IVb in 0.2% (range 0–0.5%), and Clavien V in 0.04% (range 0–0.1%) [17]. In our study, the study population was patients with renal failure and bilateral renal calculus. These patients are at a risk for renal replacement therapy; out of 27 patients, 2 (7.4%) needed renal replacement therapy in the form of transient dialysis (Clavien IVa). Furthermore, as PCNL was performed bilaterally, the blood transfusion rates (Clavien II) were higher when compared to unilateral PCNL.

Kurien et al. reported that 91 patients with chronic renal failure with renal calculi had PCNL with good clearance rates and good renal functional outcomes. Eight patients required renal replacement therapy in the form of either maintenance hemodialysis or renal transplantation. The complication of post-operative bleeding needing blood transfusions was seen in seven patients, and two of them subsequently required super-selective angioembolization for renal vessel pseudo-aneurysms [18]. Singh et al. outlined their experience of PCNL in 128 solitary functioning kidneys with renal stones. Complete stone clearance was achieved with a final stone clearance rate of 89.1%. Stage IV and V renal failure patients were associated with lower stone clearance in a single session, prolonged post-operative hospital stay, and increased incidence of higher-Clavien-grade complications and hemodialysis [19]. Proietti S et al. reported a transient increase in serum creatinine levels after bilateral supine PCNL, which settled at one month even in patients with normal baseline serum creatinine levels [20]. In our study, there was a transient increase in serum creatinine level in the immediate post-operative period, and at one month, the serum creatinine levels were significantly lower than the preoperative level. Two patients needed transient hemodialysis post-operatively.

Sofer M et al. reported that the upper calyx was successfully approached through lower calyx access in 20% of prone and 80% of supine percutaneous nephrolithotomies [21]. Furthermore, Kontos S et al. reported that upper-pole renal stones can be safely and effectively treated percutaneously using direct upper-pole puncture via an infra-costal approach in the supine position [22]. In our study, there were stones in upper calyx in four renal units, and all of them required an upper calyceal puncture. Hoznek et al. reported PCNL in the supine position under fluoroscopy guidance in patients who had unsuccessful renal access under ultrasonic guidance. A successful puncture was achieved on the first

attempt in 7 of 10 patients without any complications [23]. In the other three patients, the puncture was successful on the second or third attempt.

The limitations of this study include retrospective study design, relatively small sample size, and lack of comparative arm and cost analysis.

5. Conclusions

Bilateral tubeless supine M-PCNL in a single session for bilateral renal calculi in selected patients with renal failure is a safe, feasible, and effective option which can be carried out without increased morbidity and can be attempted if the first-side M-PCNL has proceeded smoothly within a reasonable amount of time. Further studies are required to assess its long-term impact on renal function.

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Informed Consent Statement: Patient consent was waived due to this study being a retrospective study with analysis of clinical record data, informed consent was not obtained from individual patients.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflict of interest.

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