Original Article

Lateral percutaneous nephrolithotomy: A safe and effective surgical approach

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ABSTRACT

Introduction: Percutaneous nephrolithotomy (PCNL) is traditionally performed with the patient in the prone position for large renal calculi. However, anesthetic limitations exist with the prone position. Similarly, the supine position is associated with poorer ergonomics due to the awkward downward position of the renal tract, a smaller window for percutaneous puncture, and a higher risk of anterior calyx puncture. This study aimed to demonstrate the feasibility and safety of lateral-PCNL in managing large renal calculi without the disadvantages of prone and supine positions.

Methods: Retrospectively, 347 lateral-PCNL cases performed from July 2001 to July 2015 were examined. the patient's thorax, abdomen, and pelvis were positioned over a bridge perpendicular to a "broken" table, creating an extended lumbodorsal space. The procedure was evaluated in terms of stone clearance at 3 months' postprocedure, operative time, and complications.

Results: Primary stone clearance was achieved in 82.7% of patients. The mean operating time was 97 min. The average time taken to establish the tract and mean radiation time were 4.5 min and 6.93 min, respectively. In total, 2.3% of patients required postoperative transfusion, and 13.5% of patients had postoperative fever. There was one case of hydrothorax, but no bowel perforation.

Conclusions: Our lateral-PCNL technique allows for effective stone clearance due to good stone ergonomics and it should be considered as a safe alternative even in the most routine procedures.

INTRODUCTION

Since its introduction in 1976, Percutaneous nephrolithotomy (PCNL) has generally replaced open surgery for large and complex renal calculi.[1] The traditional, and still popular, approach to PCNL requires prone patient positioning, which allows the surgeon to choose a suitable puncture site over a large surface area with considerable space for instrument manipulation.[2] However, limitations exist with prone-PCNL. First, this position is a relative contraindication for patients with a high body mass index or cardiovascular comorbidities, given excess cardiopulmonary strain. Second, prone-PCNL is difficult to perform on patients with structural deformities such as kyphosis and fixed flexion of the lower limbs.[3]

To address these limitations, other positions have been described. Supine PCNL has been touted as a promising alternative due to its benefits in patient comfort and decreased anesthetic risk. However, supine-PCNL is also associated with poorer ergonomics due to awkward downward positioning of the renal tract, a smaller window for percutaneous puncture, and a higher risk of anterior calyx puncture.[4,5]

An ideal patient position would provide good anesthetic conditions and ergonomics with minimal intraoperative complications. The lateral position meets such criteria.

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Lateral PCNL was first performed on a morbidly obese patient in 1994.[6] Further studies described the anesthetic advantage of lateral PCNL in the morbidly obese or kyphotic patients and the rotation of C-arm fluoroscopy to obtain an anterior-posterior projection and perform nephroscopy simultaneously.[7] Lateral-PCNL is also recommended in patients with severe medical risk factors and comorbidities to optimize clinical outcome.[8] More recently in 2009, lateral-PCNL has also been performed with ultrasound-guided renal access to reduce the risk of radiation dose.[9] Despite the developments of lateral PCNL, it is still not widely practiced and hence data on its use remain limited. This study aimed to demonstrate the feasibility and safety of lateral-PCNL for large and complex stones, without the disadvantages associated with the prone and supine positions.

METHODS

Retrospectively, 347 primary lateral-PCNL procedures performed by a single surgeon from July 2001 to July 2015 were examined. Our lateral PCNL procedure is explained in Video 1 (video available online at www.indianjurol.com). All PCNL for unilateral stones were performed in the lateral position by one surgeon. Only those with bilateral stones suitable for simultaneous bilateral PCNL were offered the prone position. This study was performed in accordance with the ethical standards laid down in the 1984 Declaration of Helsinki and has been approved by the institutional ethics committee. All patients provided consent. Patient demographics, stone characteristics, operative time, and location of percutaneous access were recorded.

Patients were assessed preoperatively through medical history, physical examination, urine culture, and routine hematological investigations. Only patients undergoing unilateral PCNL for the first time were included The Guy's Stone Score was used to classify stone complexity.[10] A staghorn stone was defined as a renal pelvic stone that branched into the major calyx.

Success was measured by the absence of residual stone fragments, or when clinically insignificant residual fragments (CIRFs) were observed[11] under conventional X-ray (XR) or computerized tomography (CT) abdomen. CIRFs were defined as asymptomatic, nonobstructive, and noninfectious residual fragments (≤4 mm).[12] Stone-free status was accepted as complete stone clearance or CIRF. This was evaluated 3 months after the initial PCNL. We also laid out success rates involving staghorn and nonstaghorn stones. The modified Clavien system was used to classify perioperative complications.[13]

Preoperatively, the size and location of the stones were determined using either an XRay or CT. Prior treatment was given to patients with staghorn calculi and those with infective symptoms. According to urine culture results, patients were given prophylactic antibiotics to minimize the incidence of urinary infection. With the exception of one patient, all patients received general anesthesia. Under general or epidural anesthesia, patients were positioned in an extended lateral position [Figure 1a] in two stages. First, the pelvis and trunk were placed in the lateral position over a bridge perpendicular to the operating table. Second, the table was broken while the patients remained laterally positioned. The patients were maintained in this position, with the same set of drapes used throughout the procedure.

After draping, percutaneous access was achieved under fluoroscopic guidance in the widened lumbodorsal space created by "breaking" the table, immediately behind the posterior axillary line. The C-arm was pushed into position and rotated below the table to form a "U" shape [Figure 1b]. Ureteric catheter was used to inject contrast to identify the site of puncture in all cases except if there was a prior nephrostomy tube.

An access tract was established using the triangulation technique. With the fluoroscopy tube in the horizontal position, the surgeon aimed for the desired kidney pole by

Figure 1: (a) Patient position during the procedure. Note how the pelvis and thorax are perpendicular to the surgical table. (b) C-arm Position of C arm during procedure

moving the needle craniocaudally. The C-arm was then rotated obliquely by 30° in a clockwise or counterclockwise position, depending on the position of the targeted side or calyx. Subsequently, the surgeon aimed for the posterior calyx situated nearest to the needle by moving the needle mediolaterally. The direction of the puncture needle was almost horizontal, facilitating stone fragmentation. Tract dilation was performed using serial metal dilators, and a lithotripter was used to break the stones down. Finally, a flexible nephroscope, performed using the Amplatz sheath, was advanced into the tract to remove the remaining kidney stone fragments. Patients remained in the lateral decubitus position throughout the procedure. Operative time was defined by time of "knife to skin" to time of completion of the procedure.

Upper pole puncture was favored because it provides good access to the lower pole and ureter.[14] Due to the angle in which the percutaneous access is created, the upper pole access can be performed subcostally. Broken stone fragments from any of the three kidney poles can gravitate down into the renal pelvis and can be removed readily.

Hemoglobin levels were measured on the 1st day. All patients with radiopaque stones were assessed using kidney, ureter, and bladder-XRay (KUB-XR) postoperatively after 72 h, whereas patients with nonopaque stones were assessed with noncontrast CT scans or flexible nephroscopy. Patients who were stone free had their nephrostomy tube removed. In patients with residual stones, secondary procedures including flexible renoscopy under minimal sedation, extracorporeal shock-wave lithotripsy, or secondary PCNL if the remaining stone was of significant size, were performed.

Information was obtained by reviewing notes pertaining to the operation, inpatient stay, and postoperative follow-up. Imaging reports, inpatient observation charts, and hematological results were also reviewed. The procedure was evaluated retrospectively in terms of successful stone clearance rate and complications.

RESULTS

Patient characteristics and study results are summarized in Tables 1 and 2, respectively.

The mean patient age was 48.4 years (59.9% male), mean stone size was 24.0 mm, and 34% of patients had staghorn stones removed through lateral-PCNL. In the majority of patients (77.4%), only the upper calyx was punctured to gain access to the offending renal stone. More than one access tract was needed in 5.5% of cases. Only four cases were abandoned.

Primary stone clearance was achieved in 82.7% of patients. Sixty patients required a secondary procedure, in which it is mostly explained for by significant hydronephrosis by the time the patient sought treatment. Only one case was converted to open surgery. In this particular case, the decision was made because the large upper ureteric stone was tightly impacted, and there was difficulty in reaching the stone using the nephroscope.

Table 1: Patient demographics and characteristics of stones

Parameter	Value
Mean age and range (years)	48.4 (5-78)
Sex (*n*)	
Male	208
Female	139
Stone types (*n*)	
Staghorn	118
Nonstaghorn	229
Classification (Guy's)	
1	54/347=15.6%
2	175/347=50.4%
3	23/347=6.6%
4	95/347=27.4%
Mean stone size and range (mm)	24.0 (6-87)

Table 2: Summary of results

Parameter	Value
Mean operating time and range (min)	97 (10-290)
Mean time to establish tract and range (min)	4.5 (2-18)
Mean radiation time and range (min)	6.93 (1-20)
Access (*n*)	
Upper calyx puncture	254
Middle calyx puncture	19
Lower calyx puncture	51
Supracostal puncture (puncture above the 12th rib)	4
>1 access needed	19
Stone-free rate (%)	
Overall	287/347=82.7
Nonstaghorn stones	202/229=88.2
Staghorn stones	85/118=72.0
Complications (*n*)	
Fever (temperature >38°C)	47
Significant bleeding	8
Hydrothorax	1
Conversion to open	1
Bowel perforation	0
Classification (Clavien)	
1	47/347=13.5%
2	8/347=2.3%
3A	1/347=0.3%
3B	1/347=0.3%

There were no cases of organ perforation. Only one patient experienced hydrothorax. Eight patients (2.3%) had significant bleeding, as defined by a drop in hemoglobin levels by more than two units, or if significant bleeding was clearly documented in the notes. Forty-seven patients (13.5%) had postoperative fever, as defined by a temperature of 38° and above.

The mean operating time was 97 min (range: 10–290 min). The average time taken to establish the tract (including tract puncture, dilatation, and flexible renoscopy) and mean radiation time were 4.5 min and 6.93 min respectively.

DISCUSSION

PCNL is classically performed in the prone position, and despite well-documented safety and efficacy, it is associated with considerable cardiopulmonary strain for patients. The supine position, conversely, has anesthetic advantages, but results in poorer ergonomics and increased surgical difficulty.[15] We surmise that the lateral position confers the advantages of both prone and supine positions, with very few disadvantages. This has been shown in the data series collected over 15 years, suggesting that lateral-PCNL is effective and has low rates of intraoperative complications.

The stone-free rate for patients with nonstaghorn stones was 88.2%. A study performed by Karami *et al.*[3] comparing surgical outcomes in non-staghorn stone patients who underwent PCNL in the prone, supine, and lateral positions noted similar success rates 1 month post-procedure in all positions (92%, 86%, and 88%, respectively). The stone-free rate for patients with staghorn stones using our technique was 72%. This is comparable to success rates reported in other studies (66.4%–78%).[16-19] The overall stone-free rate in our study (82.7%) is comparable to other studies, describing lateral-PCNL when patients with staghorn stones are included.[20,21] A systematic review by Wu *et al.* showed that the pooled stone-free rates in prone and supine PCNL were 83.4% and 84.5%, respectively.[21] Success rates in other existing studies on lateral-PCNL are also comparable to our study. A study in 2009 showed a 85% stone-free rate in lateral decubitus PCNL with ultrasound guidance.[9] Another study showed a 50% stone-free rate using a full lateral position in high-risk patients with the American Society of Anesthesiologists Grade 3 and above.[8]

The effectiveness of stone clearance in lateral-PCNL lies in good ergonomics. As demonstrated in Figure 2, the position of the pyelocaliceal system relative to the ureters enables gravity-assisted migration of calculi fragments from the renal calyxes into the renal pelvis for easy removal.

The operating time using our technique was also looked at in our study. A recent systematic review by Falahatkar *et al.*[22] found that the mean operating time of prone and supine PCNL was 99 min and 81 min, respectively. This is comparable with the mean operating time in our own study, which was 97 min (range: 10–290 min).

The safety of lateral-PCNL was also investigated by examining complication rates. A large window for percutaneous puncture in lateral-PCNL in the lumbodorsal space between the pelvis and ribs should, in theory, reduce the risk of perforation of adjacent organs. Supracostal puncture, and hence the risk of pulmonary injury, was only indicated in 1.1% of cases. We noted significant bleeding in only 2.3% of patients, and there were no cases of bowel perforation. There was only one reported case of hydrothorax. The rate

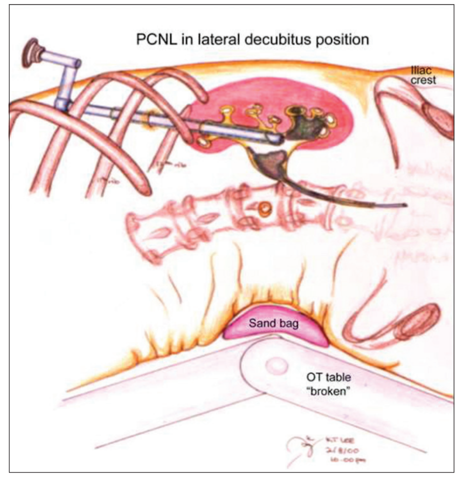

Figure 2: Gravity-assisted stone clearance in the lateral position

of significant bleeding in our study is lower than the data published for supine and prone PCNL (transfusion rates of 8.8% and 4.3%, respectively).[23] With respect to colonic perforation, patients in this study had a comparable or lower rate of bowel injury in relation to supine (0.5%) and prone (0.5%) positions.[21] Similarly, previous studies have shown fever rates (temperature ≥38°C) of 21.0%–32.1% in prone PCNL, which is higher than that reported in our study (13.5%).[24] Advocates of the supine position theorize that infection rates would be lower in PCNL positions that promote efficient fluid drainage, due to a theoretical decrease in pyelovenous backflow.[25] Indeed, such a theory may account for the relatively low fever rates noted in this study. The lateral position proposed shares the same patient position as other forms of surgical procedures for large upper renal tract stones. Therefore, if the procedure fails, or if there is a severely impacted large upper ureteric stone, our technique can be easily converted from failed PCNL to open surgery as a last resort if required.

Anesthetic advantages of the lateral position compared to the prone position have been well documented.[6,26,27] In the prone position, elevated intra-abdominal pressure causes a decrease in functional total capacity. There have also been reports of skeletal, eye, and neurological injury when patients are turned from the supine to the prone position.[9] Conversely, PCNL in the lateral position is suitable for obese patients and those who are severely kyphotic, as risks of severe hypercarbia and hypoxia are lower. This is due to reduced pulmonary compression.[7] If the patient experiences any stress or anesthetic complications, they are more efficiently dealt with in the lateral position.[8]

A number of other lateral-PCNL techniques have been proposed. The split-leg modified lateral technique by Lezrek *et al.* positions the thorax in the lateral position and the pelvis in an oblique position (45°).[28] This differs from our lateral-PCNL procedure, where the thorax, abdomen, and pelvis are positioned more laterally. The technique described by Lezrek *et al.* is best for patients needing simultaneous retrograde access, whereas the procedure described herein is suitable for routine usage. The Barts technique, introduced in 2008, is similar to the split-leg modified lateral technique, except that the legs are bent in a slightly higher position.[29] This technique has been found to be associated with difficulty in accessing the kidney with fluoroscopy.[30] The Galdakao-modified Valdivia position has also been described, where, like the split-leg modified lateral technique, the patient is positioned less lateral than the technique described in this study.[31] Unlike our technique, the aforementioned procedures have not been recommended for routine PCNL.

Nevertheless, there are limitations to the lateral-PCNL procedure. First due to obvious anatomical reasons, synchronous bilateral PCNL is impossible. Second, because of superior ergonomics, there is a higher likelihood of stone fragments migrating into the ureter. This limitation can be overcome by simple measures, such as preprocedural stenting or ureteroscopy to remove the remaining stone fragments. It is difficult to quantify the amount of fluoroscopic radiation exposure for the surgeon in our lateral-PCNL technique. However, in theory, there should not be any significant change in radiation risk. The radiation time of 6.93 min in our study was comparable to radiation times documented for prone and supine PCNL positions (7.7 and 7.8 min, respectively).[32] The intermittent use of fluoroscopy in our technique also helps in minimizing radiation risk. Alternatively, the use of ultrasonography instead of fluoroscopy can minimize radiation exposure in the lateral decubitus position with comparable success and complication rates.[9] Similarly, ideally, all patients should undergo a postoperative CT scan to determine the clearance as it is more sensitive than plain KUB-XR. However, in most straightforward radiopaque stone cases in our study, the majority of patients preferred XR after they were counseled about radiation risks and costs.

Our study was not without limitations. Given the retrospective, case series nature of the study, there is some likelihood of bias. Like many retrospective case series, there is also a risk of underestimation of the true incidence of surgical complications. Conservative definitions of clinically adverse events and the difficulty in evaluating the subjective patient experience may lead to systematic underreporting. Finally, our results should be interpreted with consideration that there are very few studies that directly compare different PCNL positions.

Given anesthetic advantages and a wider puncture site, we surmise that lateral-PCNL is safer than conventional prone-PCNL. Superior ergonomics should, theoretically, facilitate stone clearance, particularly when treating patients with staghorn stones. The disadvantages associated with lateral-PCNL can be easily overcome by simple and cost-effective measures. More randomized studies should prospectively compare patients receiving lateral-PCNL and conventional prone and supine PCNLs to further evaluate the safety and efficacy of these positions.

CONCLUSIONS

This study shows that our lateral-PCNL technique is feasible, efficacious, and safe. Nevertheless, more studies should be performed to investigate the efficacy and safety of this procedure further. Due to the advantages the lateral position potentially offers, we suggest that it should not be restricted to patients with high anesthetic risk, but should also be considered as an option for patients requiring routine unilateral PCNL.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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