Abstract  Objectives: To assess the feasibility of performing percutaneous nephrolithotomy (PCNL) with the patient supine. Although PCNL with the patient prone is the standard technique for treating large (>2 cm) renal stones including staghorn stones, we evaluated the safety and efficacy of supine PCNL for managing large renal stones, with special attention to evaluating the complications.

Patients and method: In a prospective study between January 2010 and December 2011, 54 patients with large and staghorn renal stones underwent cystoscopy with a ureteric catheter inserted, followed by puncture of the collecting system while they were supine. Tract dilatation to 30 F was followed by nephroscopy, stone disintegration using pneumatic lithotripsy, and retrieval using a stone forceps. All patients had a nephrostomy tube placed at the end of the procedure. The results were compared with those from recent large series of supine PCNL.

Results: The median (range) operative duration was 130 (90–210) min, and the mean (SD) volume of irrigant was 22.2 (3.7) L. One puncture was used to enter the collecting system in 51 renal units (94%), while three units (6%) with a staghorn
stone needed two punctures. The stone clearance rate was 91%, and five patients had an auxiliary procedure. There were complications in 15 patients (28%). All patients were stone-free at a 3-month follow-up.

**Conclusion:** Supine PCNL is technically feasible; it has several advantages to patients, urologists and anaesthesiologists. It gives stone-free rates and a low incidence of organ injury comparable to those in standard prone PCNL.

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**Introduction**

The first documented percutaneous nephrostomy (PCN) was by Thomas Hillier in 1865, but it was not until 1955 when Goodwin et al. [1] reported their work on PCN for the drainage of suppuration and urine in a hydronephrotic kidney that PCN gained widespread acceptance. In 1976 Ferstrom and Johansson [2] reported the first percutaneous procedure for stone removal and since then percutaneous nephrolithotomy (PCNL) has been shown to be effective and safe for treating large renal stones (>2 cm), including staghorn stones.

PCNL is usually done with the patient prone, as it is believed that for puncturing and dilatation of the kidney, which is a retroperitoneal organ, the posterior approach provides a large working space with a lower incidence of splanchnic and vascular injury. However, even in this position, major complications, including haemorrhage and organ injury, have been reported in 0.9–4.7% of cases [3,4]. The prone position is associated with patient discomfort, a compromised circulation and ventilation, especially in obese patients, and it is also time-consuming and increases the radiological hazards to the urologist [4].

Various modifications of patient positioning for PCNL were tried as urologists understood more of the surface anatomy of the kidney and related viscera. These included the reverse lithotomy [5], supine [6] and lateral decubitus [7] positions. These options were shown to be safe and effective compared with the conventional prone PCNL, yet were never popular. The complete supine PCNL is a tempting substitute for prone PCNL, with the potential advantages of less patient handling, a quicker operation, better drainage through the Amplatz sheath, and the ability to perform simultaneous PCNL and ureteroscopic procedures [6–8]. Although severe complications of anaesthesia are infrequently reported with the patient prone, the supine position is more comfortable for the anaesthetist, especially in obese patients at high-risk during anaesthesia [6].

Thus we assessed supine PCNL to evaluate its safety and efficacy in managing large renal stones, with special attention to evaluating the complications.

**Patients and method**

At our centre, between January 2010 and December 2011, supine PCNL was used in 54 patients (median age 39 years, range 19–62; 31 men and 23 women) with a median (range) body mass index (BMI) of 30 (17–42) kg/m².

The preoperative evaluation included history, clinical examination and routine laboratory investigations. All patients had IVU or noncontrast-enhanced spiral CT of the urinary tract to evaluate the stone location, burden and radiolucency. The stone burden was determined by measuring the longest diameter on the preoperative radiological investigations; if there were multiple calculi the burden was defined as the sum of the longest diameter of each stone.

A preoperative sterile urine culture was mandatory and patients with a positive culture were treated for 48 h before PCNL, and the treatment continued for 7 days afterwards. A third-generation cephalosporin was given as prophylaxis to patients with a sterile culture at the time of surgery, and was continued for 48 h afterwards. Staghorn stones included in the study were either one stone with branches from the renal pelvis into all major calyces, or a pelvic stone with multiple stones in at least two major calyceal groups. The median stone size was 20 mm, 12 patients had a staghorn stone, 10 had a pelvic stone, and 32 had multiple stones, with a mean stone burden of 29.7 mm (Table 1).

The procedure began with the patient in the lithotomy position, with insertion of an open-tip 7–8 F ureteric catheter, using a 22 F cystoscope. The operative duration was calculated from the time of ureteric catheter insertion until the nephrostomy tube was secured to the skin.

After inserting the ureteric catheter, the patient was placed supine with the ipsilateral arm secured to the chest, and a 3-L fluid bag under the flank. Under fluoroscopic guidance an 18 G needle was used to puncture the collecting system. Unlike in the prone position, the needle must remain almost horizontal or slightly inclined upward towards the operating table. We marked the puncture site, which lies at the level of the posterior axillary line under the level of the 12th rib, targeting the lower posterior calyces (Figs. 1 and 2).
A 0.9 mm (0.038 inch) guidewire was inserted, followed by dilatation of the tract using PTFE dilators up to 12 F; this was followed by inserting a second (safety) guidewire. The tract was dilated up to 30 F using metallic telescopic dilators (Alkan’s dilators), followed by the insertion of a 30 F Amplatz sheath.

The increased mobility of the kidney, due to the absence of support when supine, caused the guidewire to buckle, hindering tract dilatation. This was managed by an assistant supporting the patient’s abdomen, pushing it backward during dilatation. After tract dilatation we used a 27 F nephroscope with a ballistic energy source for stone disintegration.

The volume of irrigant used and the duration of fluoroscopic exposure were recorded at the end of the procedure. Haemodynamic changes and any need for transfusion were evaluated and recorded during the first 24 h after surgery.

A radiological examination was used to assess stone clearance on the first day after surgery, with either a plain film of the abdomen or CT of the urinary tract. Perioperative complications were classified according to the modified Clavien grading system [9]: Grade 1, any deviation from the normal postoperative course but with no need for pharmacological, surgical, endoscopic, or radiological intervention; Grade 2, complications requiring pharmacological treatments or blood transfusions; Grade 3, complications requiring surgical, endoscopic, or radiological intervention with no (grade 3a) or with (grade 3b) general anaesthesia; Grade 4, life-threatening complications requiring a stay in an intensive care unit (grade 4a, single organ; grade 4b, multi-organ dysfunction); Grade 5, death.

Results

The median operative duration was 130 min, and the median duration of X-ray exposure was 10 min. The mean (SD) volume of irrigant fluid was 22.2 (3.7) L. One puncture was used to enter the collecting system in 51 renal units (94%), while three renal units (6%) with a staghorn stone needed two punctures.

We used a stone size of <5 mm as the protocol for there being no need for further treatment. Of the 54 renal units treated, 49 had no or <5 mm residual fragments, resulting in a stone-free (success) rate of 91%. Of the five renal units with residual stones, two were treated by a second supine PCNL through the already present nephrostomy tract, and these were rendered stone-free. One patient with a prolonged urine leak had his ureteric catheter changed for a double pigtail stent and had ESWL 2 weeks after discharge. The other two patients had ESWL with no stent for a calyceal residual stone. All patients were stone-free at a 3-month follow-up.

Any reduction in haemoglobin level, and the vital signs, were recorded; the mean (SD) reduction in haemoglobin level was 1 (1.15) g/dL, with two patients requiring a transfusion. In our practice we remove the nephrostomy tube 2 days after surgery, and in the absence of a urine leak and/or fever, we remove the ureteric catheter 24 h afterwards.

| Variable                  | Value                      |
|---------------------------|----------------------------|
| Age (years)               | Median (range) 39 (19–62)   |
|                           | Mean (SD) 38.8 (14)        |
| Sex, M/F (n)              | 31/23                      |
| Stone site, R/L (n)       | 28/26                      |
| Stone location (n)        | Pelvis 10                  |
|                           | Pelvis + calyceal 32       |
|                           | Staghorn 12                |
| BMI, kg/m²                | Median (range) 30 (17–42)  |
|                           | Mean (SD) 30.2 (6.9)       |
| Stone burden (mm)         | Median (range) 30 (10–55)  |
|                           | Mean (SD) 29.9 (10.9)      |
| Stone radiolucency (n)    | Radio-opaque 37            |
|                           | Radiolucent 11             |
|                           | Mixed 6                    |

Figure 1 The patient position.

Figure 2 The puncture site.

Table 1 The perioperative variables of the 54 patients.
There were complications in 15 patients (28%); two had a persistent urine leak for >24 h after nephrostomy removal (4%, grade 1) and they were managed conservatively. Ten patients (19%) had grade 2 complications, with eight having a fever of >38 °C, who responded to antibiotics and antipyretics, and two had bleeding necessitating a blood transfusion (transfusion rate 3.7%). Three patients needed an auxiliary endoscopic procedure under anaesthesia (5% grade 3). There was no case of organ injury or fistula (urinary or vascular).

If there were no complications the patients were discharged on the same day that the urinary catheter was removed; the median (range) hospital stay was 5 (3–8) days. Patients were scheduled for a follow-up at 1 month and were assessed by urine culture, together with a plain abdominal film and/or CT of the urinary tract before the follow-up visit (Table 2).

**Discussion**

PCNL is widely accepted as the treatment of choice for large renal stones, including staghorn stones. It is less invasive, effective, safer and has a lower complication rate than open renal surgery [10]. PCNL is usually done with the patient prone, which carries several disadvantages to the patient, anaesthesiologist and urologist.

In 1987, Valdivia et al. [11] reported the first study on the feasibility of PCNL in the supine patient, but it was 1998 before the same authors reported their 10-year experience of PCNL with the patient supine [6], and that this technique was then reintroduced. The results were similarly good in several other reports [12–14], confirming the efficacy and safety of supine PCNL for treating most renal stones.

The supine position offers several advantages. General anaesthesia is less hazardous, no repositioning of the patient is needed, it is more comfortable for the surgeon, who can work while seated. The X-ray exposure to the surgeon during the entire procedure is decreased because the surgeon’s hands are no longer in the fluoroscopic field and stone fragments are cleared easily.

In the present study PCNL was used in 54 patients; the median (range) and the mean (SD) BMI were 30 (17–42) and 30.2 (6.9) kg/m², respectively, denoting that most patients included in the study were overweight. The median (range) operative duration, including the time of ureteric catheter insertion, was 130 (90–210) min. Mean operative times of 85 and 98 min were reported by Valdivia et al. [6] and Falahatkar et al. [14], respectively (Table 3) [12]. Hoznek et al. [12] reported a mean (range) operative duration of 123 (50–245) min.

Puncturing the upper calyces with the patient supine is almost impossible, but staghorn stones were amenable to

| Table 3 Evaluation of outcome in a series of supine PCNL for large stones. |
|-----------------------------|-------------------|---------|---------|---------|
| Variable                    | Study             | [12]    | [15]    | [14]    | [6]     | [16]    |
| Renal units                 |                   | 47      | 53      | 117     | 557     | 39      |
| Mean (range) stone burden   |                   | 29 (10–75)| NA     | 36 (10–80)| NA     | 34 (25–51)|
| Staghorn stones, n (%)      |                   | 7 (14)  | 3 (5.6) | 11 (9)  | NA      | 0       |
| Mean (range) operative      |                   | 123.5 (50–245)| NA   | 98 (20–180)| 85(15–240)| (25–120)|
| Duration (min)              |                   | 38 (81) | 47 (89) | 91 (77.5)| NA      | 34 (88.7)|
| Stone-free rate, n (%)      |                   | 1 (2)   | 5 (9)   | 17 (14) | 8 (1.4) | 0       |
| Transfusion rate, n (%)     |                   | 0       | 0       | 0       | 0       | 0       |
| Organ injury, n (%)         |                   | 3.4 (2–12)| 2.5    | 3.2 (1–7)| NA      | 4.3 (2.2–8.4)|

NA, not available.
treatment during supine PCNL. The present study included 12 patients with staghorn stones (22%) for whom the median (range) stone burden was 30 (10–55) mm. Seven patients (14%) with a staghorn stone were included in the study of Hoznek et al. [12]. Falahatkar et al. [14] included 11 patients (9%) with a staghorn stone in their study (Table 3).

The stones were cleared in 49 (91%) of the present patients; this was a better rate than reported by Hoznek et al. [12] and Falahatkar et al. [14], who achieved a stone clearance rate of 81% and 77.5%, respectively. This might be because the stone burden in the present study was less than in the other two. Shoma et al. [15] found a stone clearance rate of 89% in their study that included 53 patients. A similar result was given by De Sio et al. [16], who reported a stone clearance rate of 88.7% in their study of 39 renal units.

There were complications in 15 of the present patients (28%), graded according to the Clavien system, but most of the complications were of grade I and II (23%). There was bleeding requiring a transfusion in 14% of the cases. Grade III complications were present in 7% of patients; this was a better rate than reported by Hoznek et al. [12]. Falahatkar et al. [14] reported a stone clearance rate of 91%, and 88.7% in their study of 39 renal units.

In a meta-analysis of the supine vs. the prone PCNL positions in the last 35 years [19], evaluating their safety, advantages and limitations, the authors concluded that there was no perfect position for PCNL, and that ‘Urologists who perform PCNL should be familiar with the differences in the positions and be able to use the method appropriate for each patient’.

The present study has several limitations; it included a relatively small sample, and although it included patients with staghorn stones, the stone burden was relatively low. This was a descriptive study lacking a comparative arm and was not randomised.

In conclusion, supine PCNL is technically feasible, has several potential advantages, especially in patients at high risk when under anaesthesia, and can be used to treat all stone sizes. There is no apparent added risk in using this technique, and the stone clearance and complication rates are within the accepted values cited previously for the standard prone PCNL.

Conflict of interest

No conflict of interest to declare.

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