

# Implementation of supine percutaneous nephrolithotomy: a novel position for an old operation

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**Introduction** Supine percutaneous nephrolithotomy (PCNL) has become increasingly widespread during the last 2 decades.

The aim of this study was to analyze the transition from prone to mainly supine PCNL in 2 endourologic centers.

**Material and methods** We retrospectively analyzed data on 214 consecutive supine PCNLs divided into the first (2011–2013) and last (2014–2016) 3 years of this study. The first 27 cases were also included in a randomized controlled trial (RCT) by comparison with 24 prone PCNLs. We compared the clinical outcome and implementation rate. The surgical team was surveyed for their overall impression of performing supine PCNLs.

**Results** The RCT revealed a trend toward shorter operative time (138 vs. 150 minutes), anesthesia time (174 vs. 192 minutes) and hospitalization (2.2 vs. 2.6 days) in the supine PCNL group, without statistical significance and similar stone free rates (SFR) as for the prone PCNL group. Implementation of the supine PCNL reached 96% in 3 years. There was a decrease in operative time (110 vs. 154 minutes;  $P < 0.0001$ ), hospital stay (1.5 vs. 2.1 days;  $P < 0.01$ ), blood transfusion (5% vs. 14%;  $P < 0.05$ ) and rate of ancillary procedures (5% vs. 16%;  $P < 0.05$ ) in the last 3 years of the study. SFR remained stable. Both the surgeons and anesthesiologists expressed their unanimous preference for the supine position over the prone position.

**Conclusions** Supine PCNLs are easy to implement without a significant learning curve for an experienced endourologist. They can be employed in complex cases and improve surgeon's ergonomics and anesthesiologist's access to the patient.

**Key Words:** calculi ↔ supine percutaneous nephrolithotomy (PCNL) ↔ supine

## INTRODUCTION

Large and complex renal calculi represent one of the most challenging urological pathologies. Affected patients are exposed to renal functional deterioration, recurrent infections, and repeated endourologic interventions. Percutaneous nephrolithotomy (PCNL) is the treatment of choice in these cases [1, 2]. First reported in 1976, PCNL was progressively established as a procedure performed in the prone position [3–6]. This position was chosen intuitively, based

on anatomical considerations related to the posterior retroperitoneal location of the kidneys, the short access to posterior calyces situated on the avascular line of Brödel, the reduced risks of interposition of other viscera along the working tract, and the large surface area for puncture [7]. Prone PCNL became widely popularized and totally replaced open renal stones surgery, emerging as the standard operation and exclusive position for 2 decades. Aiming to reduce patient-, anesthesia- and surgery-related inconveniences of the prone position, Valdivia et al. [8]

described the performance of PCNL with the patient in the supine position in 1987. Supine PCNL enables a single positioning throughout the entire operation, easier patient ventilation, protection of the patient from positional injuries, more convenient access to the patient by the anesthesiologist, an improved ergonomic environment for the surgical urologist (who may be seated while operating), and an easy endoscopic combined intrarenal surgery (ECIRS) approach if needed [8–14].

Despite these advantages, the popularity of supine PCNL among urologists worldwide remains modest and is still considered a ‘new’ rather than an alternative position [2, 15]. This may be accounted for by a conservative viewpoint on the part of physicians and by the traditional consensus that treatment of a large and complex stone should be by a prone PCNL [16, 17]. This paradigm was challenged in a recent study that revealed effective endoscopic surveillance of the intrarenal collecting system through a lower calyx supine PCNL [18].

This report analyzes the effect that supine PCNL implementation has had in terms of the outcome of the initial series of patients, and it addresses various issues related to the assimilation of this new approach in two medical centers with dedicated endourologic facilities.

## MATERIAL AND METHODS

The registries of patients treated by PCNL in 2 academic institutions were analyzed from January 2011, when supine PCNL was first implemented, until October 2016. The data also included an initial prospective randomized controlled trial (RCT) that compared supine to prone PCNL between January 2011 and November 2012, after which all patients referred for PCNL were scheduled for the supine position unless there were special considerations for operating in the prone position (e.g. other organ interposition on the planned puncture tract, horseshoe kidney with lower calyx and isthmus adjacent stones, hepato- or splenomegaly with lateral kidney wrapping in patients with severe portal hypertension, etc.). Our percutaneous treatment indications conform to the international guidelines [1], and patients presenting with indications for bilateral percutaneous treatment are offered a single-session bilateral PCNL.

There were 255 PCNLs performed on 248 patients, of which 214 were performed in the supine position and 41 in the prone position. This group includes the RCT of the first 51 PCNLs, 27 of them supine and 24 prone, according to the statistical powered design and randomization. The current study was designed to analyze the 2 RCT study groups as

well as all the supine PCNLs that followed it until study closure. The RCT groups had been compared in terms of demographics, preoperative clinical data, operative time, postoperative outcome, hospital stay, rate of tubeless procedures, stone-free rates (SFR) as demonstrated on postoperative non-contrast computerized tomography (NCCT), and complications as classified by the Clinical Research Office of the Endourology Society (CROES) Clavien validated score [19]. The supine operations were analyzed separately for outcome and rate of supine position implementation. In addition, in order to assess whether there had been any changes in outcome over time, the entire supine series was arbitrarily divided into 2 groups for comparison: one group included patients operated during the first 3 years of this 6-year study and the other group included patients operated during the last 3 years.

The surgical team was comprised of 2 chief surgeons, 4 assistant surgeons, 8 anesthesiologists and 8 assistant nurses. At the end of each operation, each of them indicated which approach they preferred, supine or prone.

All procedures were intended to be accomplished in a tubeless fashion whenever possible. That means avoiding postoperative nephrostomy tubes while leaving an internal stent with an external tether. The supine position involves placement of the patient at the edge of the table, with a flank elevation of 15–20 degrees and the ipsilateral arm padded on an arm support while the legs are in either an asymmetrical lithotomy position or slightly abducted in a straight position. Using a flexible cystoscope, a guidewire followed by a ureteral catheter is inserted into the renal pelvis and a Foley 14 Fr catheter is left in the bladder. A retrograde pyelography is performed, and the puncture is carried out under combined fluoroscopic-ultrasonic guidance. Once access is gained, a guidewire is passed down to the bladder and the tract is dilated by a balloon, leaving a working sheath of 24–30FR inside the kidney. Ultrasonic and pneumatic lithotripsy is carried out through rigid nephroscopy, followed by flexible nephroscopy and real-time fluoroscopy to ensure complete stone clearance. A nephrostomy tube is left only in cases of significant bleeding or an expected need for a second-look procedure. Otherwise, an internal stent is placed and the wound is sutured. Further details on our techniques have been reported elsewhere [18, 20].

For patients left with a nephrostomy tube, NCCT was performed on the first postoperative day in order to decide whether there was a need for a second-look PCNL. Otherwise, the patients were released home and the stents were extracted by the patients

themselves during the week after the operation. Follow-up in the outpatient clinic at one month postoperatively included a complete blood count, creatinine test, urinary culture and NCCT. Since the wounds were closed with resorbable sutures, there was no need for their removal.

Statistical assessment was by comparison of continuous data by analysis of variance (ANOVA) and discrete variables by Fisher's exact and chi-square tests. A P value <0.05 was considered significant for all analyses.

## RESULTS

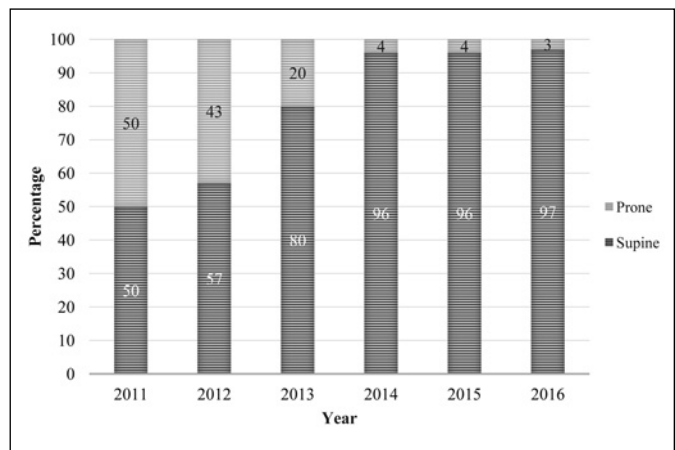
Statistical assessment of the participants in the RCT conducted between January 2011 and November 2012 that compared supine to prone PCNL revealed that they had similar demographics, clinical data and outcome (Table 1). There were 2 (7%) complications in the supine group, including one skin infection (Clavien gr. 2) and one arterial pseudoaneurysm treated by selective angio-embolization (Clavien gr. 3A). There were 5 (21%) complications in the prone group, including 3 urinary tract infections (Clavien gr. 2), 1 patient with bleeding that necessitated blood transfusion (Clavien gr. 2), and 1 patient with a small bowel perforation that was treated surgically (Clavien gr. 3B). Although the overall average anesthesia time [from introduction of a vein-line until removal of the tracheal tube (174 vs. 192 minutes)], operative time [from positioning of the patient until completion of wound suturing (138 vs. 150 minutes)] and hospital stay (2.2 vs. 2.6 days) tended to be shorter in the supine group compared to the prone group, the differences did not reach a level of significance.

The second analysis looked at the entire supine PCNL group that consisted of the 27 patients in the RCT as well as 180 patients who succeeded them. There were 207 unilateral and 7 bilateral same-session procedures that were performed on 207 patients whose average age was 55 years (range 2–87). The average maximal diameter of the stones was 34.4 mm (range 10–80), and 33 (20%) procedures were performed for staghorn stones. Twenty-one (10%) patients had been previously operated, of them 14 by prone PCNL, 6 by open nephrolithotomy and 1 by laparoscopic pyelolithotomy. The average operative time was 121 minutes (range 40–283) and the average hospital stay was 1.7 days (range 1–13). There were 151 (71%) tubeless procedures, of them 13 (8%) totally tubeless. Blood transfusions were administered in 15 (7%) cases, and there were 15 (7%) patients who developed other complications. The complications as classified by the Clavien score were 24 grade 2 (80%), 2 grade 3A (7%), 3 grade 3B (10%) and 1 grade 4A (3%). The

**Table 1.** Demographics, clinical and outcome data of the random controlled trial (January 2011 and November 2012) comparing supine PCNL to prone PCNL

Criteria	Supine (n = 27)	Prone (n = 24)	P value
Age (yr)*	59.5	56.8	0.49
Male/female	9/18	9/15	0.49
Right/left	11/16	13/11	0.24
Stone maximal diameter (mm)*	30.9	30.8	0.97
Staghorn stones	6 (22%)	8 (33%)	0.28
Body mass index (kg/m <sup>2</sup> )*	30.9	28.4	0.09
Anesthesia time (min)*	174	192	0.30
Operative time (min)*	138	150	0.46
Blood transfusion, n	1 (4%)	1 (4%)	0.72
Complications, n	2 (7%)	5 (21%)	0.16
Tubeless procedures, n	13 (48%)	10 (42%)	0.42
Ancillary procedures for residual stones, n	1 (4%)	4 (17%)	0.14
Hospital stay, n (days)*	2.2	2.6	0.30
Stone free after ancillary procedures, n	25 (94%)	22 (92%)	0.44

\*Average; PCNL – percutaneous nephrolithotomy



**Figure 1.** Supine percutaneous nephrolithotomy rates correlated to years of study.

initial SFR was 88% and it increased to a final SFR of 94% after residual stones were treated by ureteroscopy in 3 cases, retrograde intrarenal surgery (RIRS) in 8 cases and SWL in 5 cases. Six patients with small residual fragments were left for clinical follow-up. The rate of supine PCNL implementation over time reached a steady 96–97% within one year after the end of the RCT (Figure 1).

We operated 3-fold more patients during the last 3 years of the study. Those patients were younger, the operative time and hospital stay were shorter,

there were fewer blood transfusions, and there was a higher rate of tubeless operations and a lower rate of ancillary procedures (Table 2). After excluding the parameter of blood transfusions, there were no changes in the complication rate or the Clavien score distribution in time. The SFR range of 90–95% remained stable as well.

All surgeons and anesthesiologists expressed their preference for the supine position, while the other members of the surgical team had no preference for one approach over the other.

## DISCUSSION

PCNLs were introduced into the endourologic armamentarium 40 years ago [3]. All the pioneers who progressively established the principles of the PCNL operative technique were in consensus that this intervention should be performed with the patient in the prone position [3–6]. Their rationale in choosing the prone position was based on intuitive and anatomical considerations. Since then, PCNL has been undergoing a continuous process of implementing new technologies and devices which, together with the experience gained in high-volume centers and shared through educational programs, have resulted in increased safety, efficacy and decreased operating time and hospital stay [7]. This wide popularization of the procedure resulted in not only understanding its advantages over open nephrolithotomy but also in recognizing the inconveniences related to the patient's prone position on the operating table. For example, the operation begins in the lithotomy position and needs to be changed after the initial preparations to the prone position. Moreover, limitations are imposed upon the anesthesiologist in terms of access to the patient for providing ventilation and monitoring the airways during the operation. Other drawbacks include relatively increased pressure in ventilation, inadequate conditions for combining PCNL with an RIRS procedure and ergonomic inconvenience for the surgeon. These circumstances inevitably led to the search for solutions of problems related to patient position.

The solution that was ultimately postulated by Valdivia et al. [8] in the late 90s consisted of the substantial modification of switching the patient's position from prone to supine. A supine position addresses all the disadvantages related to the prone position listed above. Specifically, it allows a single positioning of the patients throughout the entire operation, it facilitates patient monitoring and ventilation by the anesthesiologist, it enables a combination of PCNL and RIRS, and it provides the surgeon with the option of operating in a seated position [7, 8, 9].

**Table 2.** Comparison of demographics, clinical and outcome data of supine PCNL during the first and last 3 years of study

Criteria	2011–2013 (n = 51)	2014–2016 (n = 163)	P value
Age (yr)*	61 (25–87)	54 (2–87)	<0.01
Stone maximal diameter (mm)*	33.5 (7–80)	35.5 (10–80)	0.15
Staghorn stones, n	12 (24%)	31 (19%)	0.30
Body mass index (kg/m <sup>2</sup> )*	30.1 (18–42)	29.4 (19–45)	0.90
Operative time (min)*	154 (80–283)	110 (40–251)	<0.0001
Blood transfusion, n	7 (14%)	8 (5%)	<0.05
Bilateral same-session PCNL, n	0	7 (4%)	0.14
Complications, n	8 (16%)	22 (13%)	0.42
Tubeless procedures, n	24 (47%)	127 (78%)	<0.0001
Ancillary procedures for residual stones, n	8 (16%)	8 (5%)	<0.05
Hospital stay (days)*	2.1 (1–13)	1.5 (1–10)	<0.01
Stone-free after ancillary procedures, n	46 (90%)	155 (95%)	0.17

\*Average; PCNL – percutaneous nephrolithotomy

The initial series of 557 patients successfully treated in the supine position was followed by other studies confirming that there were no limitations in terms of stone size, bilateral same-session performance, tubeless approach and treatment of pediatric patients [9, 11, 14, 21, 22].

Despite these advantages, the popularity of supine PCNL among urologists worldwide remains modest, reaching an overall implementation rate of around only 20% [2]. According to a 2008 CROES study, supine PCNL is practiced solely in Europe and South America and not at all in North America [15]. This may not only be due to a conservative attitude of the endourologic community, but also to a traditional consensus that treatment of a large and complex stone should be done through an upper calyx access with the patient in a prone position [16, 17]. This consensus, however, appears to rely upon expert opinions derived from a series of prone PCNLs, rather than upon updated evidenced-based data. A recent study that compared supine to prone PCNLs challenged this paradigm, revealing that a lower calyx access in the supine position allows effective endoscopic surveillance of the intrarenal collecting system, similar to that of an upper calyx access in a prone PCNL [18].

The present study describes the implementation of supine PCNLs that was introduced in 2011, in 2 academic referral centers with a high level of expertise in prone PCNLs. The leading endourologists have completed a two days observational accommodation to the procedure in European centers.



Because there were few high evidence-based studies in the literature on the positional issue until 2011, our plan for introducing supine PNL started with conducting a RCT. This trial yielded similar clinical outcomes for both the prone and supine positions. Taken together with the advantages of the supine position in terms of anesthetic and surgical considerations, we subsequently adopted the supine PCNL as our procedure of choice. Our current results reflect a period of progressive accumulation of experience over time, leading to a shortening of operative time and hospital stay, fewer postoperative ancillary procedures to render patients stone-free, and an increase in the rate of procedures performed without leaving a postoperative nephrostomy tube in place. Tubeless procedures are reportedly associated with shorter hospitalization [23]. It is entirely possible that the increase in the rate of tubeless procedures in our institutions contributed to the shortening of hospital stay during the last 3 study years. Finally, the surgeons and anesthesiologists involved in the treatment of these patients overwhelmingly preferred the supine PCNL.

To the best of our knowledge this is the first study to evaluate the transition process from prone to supine PNL and by that, it may enrich the general knowledge regarding adoption of this approach in other institutions.

We are aware that our study has some limitations. One of them is that most of the enrolled patients were assessed retrospectively. However, combining the findings of the RCT with a large series of consecutive patients that succeeded them provided us with what we believe are substantial data to support the conclusions of our study. The lack of standardization in assessing the need for blood transfusion between the participating institutions could pose a limitation, although, the rate of blood transfusions was similar and decreased significantly during the last 3 years of the study in both of them.

In conclusion, we believe that the supine PCNL approach has already passed the point of needing to prove safety and feasibility. It is an established procedure and one that is easily implemented in centers with experience in PCNLs. It facilitates the solutions for a variety of anesthesiology and endourology issues, and may be routinely used for all kinds of calculi. Our enhanced surgical outcomes with supine PCNL may contribute to further popularization of this procedure among endourologic surgeons.

#### CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

#### ACKNOWLEDGMENT

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