Comparison of Hemodynamic Stability and Pain Control in Lateral and Prone Positions in Patients Undergoing Percutaneous Nephrolithotomy: A Randomized Controlled Trial

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Purpose: Percutaneous nephrolithotomy (PCNL) is the preferred surgical treatment in many cases of kidney stones which is performed in different positions such as prone, lateral, and supine. This study was designed to evaluate whether patient position (lateral versus . prone) has an effect on the need for analgesia and onset of pain after surgery.

Materials and Methods: Patient with confirmed kidney stones (size $\geq$ 2 cm) who were candidates for PCNL were enrolled in this study. The required biochemical analyses were performed preoperatively. All patients underwent spinal anesthesia by the same anesthesiologists and then were randomly divided into two separate groups as lateral (L) and prone (P) positions. The operations' start and end time, required time for proper access into target calyces, additional need for analgesic or cardiac drugs, duration of analgesia, and onset of pain after PCNL were carefully recorded and then compared between the two groups.

Results: In total, 51 patients were evaluated of whom 39 were men and 12 were women. Mean duration of analgesia after PCNL surgery in P group (173 ± 8 min) was significantly longer than in L group (147±12 min) (P = .001). Furthermore, the amount of ephedrine usage in L group (3.6 ± 1.5mg) was significantly lower than in the P group (16.4 ± 12mg), suggesting more hemodynamic variations in the P group during the operation.

Conclusion: Our randomized control trial study shows that choosing the optimal position in the PCNL technique depends on patient's condition. If hemodynamic control is of matter to the anesthesiologist, then lateral position is more appropriate. However, if control of pain and longer time of analgesia are important, prone position may be preferred.

Keywords: analgesia; lateral position; percutaneous nephrolithotomy; prone position.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a routine surgical technique for removing kidney stones which is performed by a minimally invasive intervention through a small incision in the flank area[1,2]. In comparison with other therapeutic procedures for kidney calculi such as shock wave lithotripsy (SWL), PCNL has considerable advantages such as high stone–free rate of up to 95%, shorter post-surgical recovery period, and similar recurrence rate. Nevertheless, PCNL has lower surgical risks and lower surgical infection[3-5]. Therefore, PCNL has great clinical utility and is the preferred choice for removing kidney stones especially in patients with staghorn calculi larger than 20 mm[5]. Choosing the proper position for patients undergoing PCNL is an important issue[6,7]. It has been strongly suggested that an appropriate position can help anesthetists to keep normal airway circulation, and support optimal analgesia and better control of pain during operation (8). Also, it allows direct access to the kidneys for urologists leading to shorter duration of operation and lower incidence of hemodynamic problems i.e. bleeding and hypovolemia[6,9].

In 2016, Mak and colleagues demonstrated that prone position is followed by more hemodynamic changes than supine position, though it reduces the risk of visceral organ injury during operation[10]. In 2018, Gan and coworkers reported that lateral position in patients undergoing PCNL significantly reduces the duration of operation, decreases the need to transfusion after operation and provides greater stone clearance[11].

However, there have been no prior RCT studies directly comparing these two methods. Therefore, in this randomized controlled trial study, we have compared the two positions of lateral and prone position concerning the onset of PCNL-induced pain and hemodynamic changes in patients undergoing PCNL operation.

MATERIALS AND METHODS

Study Population

Our study was a randomized clinical trial conducted from December 2015 to December 2016 in the urology unit of Labbafinejad University Hospital, Tehran, Iran. The inclusion criteria were patients aged between 18-65 years with kidney stones (size ≥ 2 cm) who were

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Received October 2018 & Accepted September 2019

Table 1. Demographic data of patients undergoing PCNL surgery

	Lateral position	Prone position	*P*-value
Total Number (n)	26	25	-
Male (n)	21	18	.46
Female (n)	5	7	
Age ,years Mean (SD)	43.5 ± 10	42.8 ± 11	.8
Weight(kg) Mean (SD)	72.8 ± 7	74.8 ± 7	.3

scheduled for PCNL with an informed consent for spinal anesthesia. The exclusion criteria were age < 18 years or > 65 years, patients with cardiovascular or respiratory disorders, coagulopathy disorders, any history of addiction, current pregnancy, and patients with scattered stones that required multiple access tracts, and considerable rise of blood pressure (30% from baseline) or heart rate (30% from baseline) during the operation. The study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences and each patient provided informed consent before inclusion in the study. The study was registered at www.clinicaltrials.gov (NCT03966599).

Initially, 112 patients were enrolled in the study but 61 were excluded from the final analysis. Of those 61 patients who were excluded, 15 were younger than 18 years old, 10 had coagulopathy disorders, 6 had multiple stones that required several access tracts, and 30 patients had cardiovascular or respiratory disorders. The remaining 51 patients were included in the final sample and were randomly divided into two groups with respect to position (lateral: 26 patients, prone: 25 patients). Randomization was performed using a table of random numbers generated by random allocation software[12]. All of the surgeries were performed by senior fellows under direct supervision of an expert endourologist. **Table 1** summarizes the preoperative baseline characteristics for the patients in the two groups.

Before PCNL

Prior to surgery, patients fasted for at least 8 hours. Complete biochemical analysis including CBC (complete blood cell count), CT (clotting time), Cr (creatinine), Urea, BT (bleeding time), BG (blood group) and Rh, U/A (urine analysis) and U/C (urine culture) was performed on the blood and urine samples collected from patients. Also, the size and location of calculi were precisely detected by CT scan (computed topography scan) and IVP (intravenous pyelogram) techniques. Hemodynamic parameters including HR (heart rate), BP (blood pressure), SBP (systolic blood pressure), DBP (diastolic blood pressure) and SPO2 (peripheral capillary oxygen saturation) were monitored carefully before, during, and after the surgery.

Anesthesia process

After injection of normal saline (500mL), the patients were spinally anesthetized using Bupivacaine (%5; 4mL) into L2-L4 of spinal cord. Then some patients (group L) were positioned into the lateral state same side to calculi for 5 minutes, but the other patients (group P) were not. Finally, all the patients (group L&P) were positioned into supine and lithotomy states respectively for intra-ureter catheterization under guide of cystoscopy.

PCNL Procedure

Initially, in the lithotomy position and under cystoscopy guide, a catheter (6F) was inserted into the ureter through urinary tract and after that all of the patients were positioned into prone state. Then, after checking the precise stone location using C-arm through the abdominal wall, access needle guide (18 gauge) was inserted into the calyx by fornix. After confirming the urine output, the guide wire (0.35 inch J-tip) was inserted into the targeted calyx. For the patients with hydronephrosis, normal saline (50mL) was injected through the catheter to create more contrast. The nephrostomy tract was then dilated using Amplatz of F30 or F28 and then, F30 sheath was directed to the target location.

In case of any considerable reduction (30% from baseline) in HR or BP or SBP (systolic BP), patient was given an intravenous ephedrine and atropine (10 mg and 0.02 mg/kg, respectively). Patient who had significant rise (more than 30% of patient's baseline value) in HR or MAP (mean arterial pressure) were excluded from the study. Furthermore, in case of shivering or pain during PCNL, pethidine (0.55mg/kg) and fentanyl (1µg/kg) were administered respectively.

After PCNL

In the recovery room, return of sensation was assessed by pinprick test and as soon as any feeling of pain was sensed, the exact time was recorded. 48 hours after PCNL, all patients were monitored by KUB (kidney, ureter, and bladder) X-ray and ultrasonography examinations regarding any possible remaining stones in kidneys and urinary residues in the bladder.

Primary outcome

Our primary outcome was the first recorded time of

Table 2. Size and location of calculi and number of attempts for reaching the stones

		Lateral (n= 26)	Prone (n= 25)	*P*-value
Stone location	Low Position	24	21	.3
	High Position	2	4	
Size of kidney stone(mm)				
Mean (SD)		33.0±7.6	29±5.9	.1
Mean number of attempts (SD)		1.1±0.3	1.0±0.3	.7

Abbreviations: mm, millimeter

Table 3. Sensory levels after 20 min, first pain sensation and need for fentanyl and ephedrine in the prone and lateral position groups

		Lateral (n= 26)	Prone (n= 25)	*P*-value
Sensory Level				
After 20 min	T4	1	1	.99
	T5	7	7	
	T6	18	17	
Recorded time of first pain/sense (min)				
Mean (SD)		147 ± 12	173 ± 8	.001
Fentanyl(µg)				
Mean (SD)		15 ± 2.3	10 ± 2	.01
Ephedrine(mg)				
Mean (SD)		3.6 ± 1.5	16.4 ± 12	.001

pain sensation in the recovery room and need for analgesic injection.

Secondary outcome
Hemodynamic changes including blood pressure and pulse rate changes during recovery room were the secondary outcomes.

Statistical Analysis
At first, a pilot study was designed to determine the exact sample size. After evaluation of the patients, we determined the onset of pain sensation in lateral group as 130 min and in the prone group as 170 min. Considering a level of a = 0.05, study power of 80%, , and a 20% possibility of failure, a sample size of at least 15 patients was considered for each group.
Normal distribution of data was assessed by Kolmogorov–Smirnov test. Then, the data were analyzed via one-way ANOVA in SPSS software with $P \leq .05$ considered as a significant difference.

RESULTS
The Consolidated Standards of Reporting Trials (CONSORT) diagram in **Figure1** shows the process for participant inclusion. The two groups were similar in their baseline characteristics (**Table 1**).
In 92% of the L group and 86% of the P group patients, kidney stones were in a low position. The mean size of the stone was 29 ± 5.9 and 33.0 ± 7.6 mm in P and L groups. The mean number of total attempts to accessing the calculi under ultrasonography monitoring was 1.0±0.3 in P and 1.0 ± 0.3 times in L groups, which had no significant difference (**Table 2**).
At T6 level, 69% of the L and 68% of the P groups, and at the T5 level, 26% from the L and 28% from the P groups experienced returned sensation 20 min after anesthesia, showing no significant difference in the extension of sensation after surgery (**Table 3**). The first recorded time of pain sensation in the recovery room was 147 ± 12 and 173 ± 8 min in L and P groups respectively, indicating a significant difference between the groups (P = .01) (Figure 2). The patients in the L group received more fentanyl (15 ± 2.3µg) than P group (10 ± 2µg), indicating higher pain occurrence in the L group compared to the P group . However, prone positioned patients received more ephedrine (16.4±12mg) than laterally positioned patients (3.6 ± 1.5 mg), implying greater hemodynamic changes in the P group (P = .001) (**Table 3**).

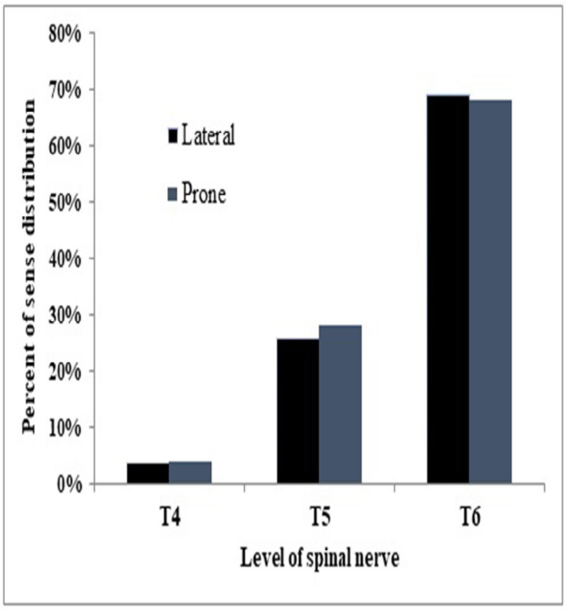

Figure 1. Distribution of sensation at various levels of spinal cord at the same time after anesthesia

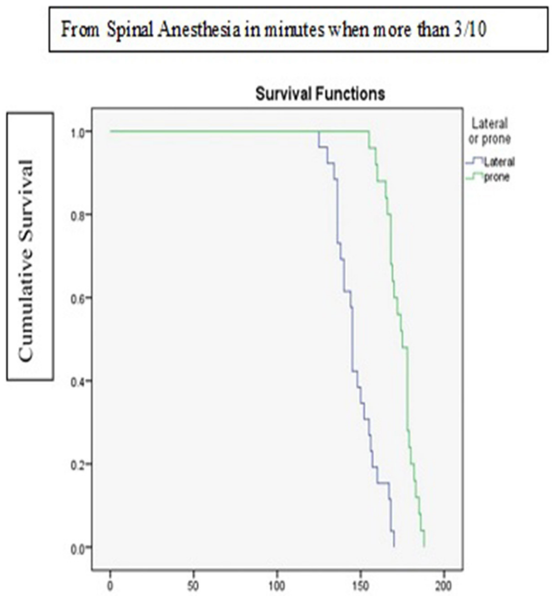

Figure 2. Kaplan-Meyer showing survival time of analgesic drugs effects in the two groups of prone and lateral positions. As seen, patients with prone position analgesic drugs had a longer duration

DISCUSSION

Choosing the proper position in the PCNL technique depends on patient's conditions. This study showed if hemodynamic control matters to the anesthesiologist, the lateral position is more appropriate; however, if the control of pain and longer time of analgesia are important, the prone position should be preferred.

PCNL is a common low-intervention surgery for removing complex and large kidney calculi [9]. However, operation duration, hospitalization period, post-operative narcotic analgesic need and cost were found to be significantly lower in the SA group. In the light of this data, it was shown that PNL can be performed more effectively, safely and with a lower cost using spinal anesthesia[9,13]. Our study reached the conclusion that bupivacaine, which is a local anesthetic agent with long-lasting ef¬fects, decreases pain scores only in the second postoperative hour. While no significant difference was found among the groups in terms of the total amount of analgesics used, there was a tendency to need low¬er amounts of narcotic analgesia in patients provided with a higher concentration of bupivacaine. The an¬algesic administration frequency was reduced signifi¬cantly in both dosages of bupivacaine[9,14]. The traditional position for patient undergoing PCNL is prone which is used by most urologists[7]. However, other positions such as lateral and supine have been suggested to possibly reduce the pain and provide better access to stones during the operation[6].

In the current trial study, we evaluated the outcomes of two positions as lateral and prone in need for analgesia drugs and the onset time of pain after PCNL surgery. Our results demonstrated that PCNL operation in the prone position may delay the onset of post-surgical pain and decrease the need for analgesia as compared with patients undergoing PCNL in the lateral position. However, more hemodynamic variations were observed with the prone position.

Karami and coworkers in 2013 reported that PCNL in both supine and flank positions are as effective and safe as prone position[15]. They found that these positions do not make any significant difference regarding the time of operation, mean access duration, and pyelocaliceal perforation during PCNL[15].

We did not find any strong evidence comparing lateral and prone positions with regards to the onset of pain and need for analgesia after PCNL. Our study demonstrated for first time that lateral position in patient undergoing PCNL surgery can provide more analgesia using the same dose of analgesic drugs as compared with patients positioned in the prone state. This outcome was accompanied by the same sensations at spinal levels indicating that the lateral position can only delay the onset of pain sensation and does not affect sensory signals.

DasGupta et al. in 2013 suggested that lateral position may provide better allowance for anesthesiologists to control airways, although they concluded that there is no obvious superiority for a position and it is dependent on the patient conditions (e.g. lateral position for obese subjects)[16].

In none of the previous articles, the level of analgesia and onset of pain after surgery were examined and our finding is novel in this regard. Hemodynamic changes in prone and supine positions have been compared in a study[17]. In 2012, Khoshrang et al. , stated that hemodynamic changes are less in the supine status as compared to the prone after comparing 40 patients [17]. However, no study compared hemodynamic changes between the two groups of prone and lateral positions. As ephedrine was used more in the P group than in L group in our study, it seems that prone position is followed by more hemodynamic variations, although it needs further investigations.

There are several strengths in this study. The study was designed as RCT which prevent biases from sampling and retrospective studies. All spinal procedures were done with the same anesthesiologist. As to our knowledge, this is the first study that compared pain control and hemodynamic stability outcomes in lateral and prone positions in PCNL. Low sample size was our limitation.

CONCLUSIONS

Proper positioning is a key issue in patients undergoing PCNL surgery. In this randomized controlled trial study, and for the first time, we have successfully demonstrated that lateral position provides more analgesia and delays the onset of post-surgical pain after PCNL.

Overall, according to anesthesiologists, prone position is preferred due to lower post-surgical pain and delayed onset of pain after PCNL. However, concerning hemodynamic variations, lateral position is preferred to prone. It is again emphasized that, in the view of the anesthetists; choosing the right position depends on the priorities. For more comprehensive results, further clinical trials are still required.

CONFLICT OF INTEREST

The author declares no conflict of interest in this study.

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