Original Research Article

Evaluation of efficacy of percutaneous nephrolithotomy in prone versus supine positions

ABSTRACT

Aims: To compare between supine and prone percutaneous nephrolithotomy (PCNL) in the management of renal stones regarding stone free rate, operative time and fluoroscopy time.

Methodology: A retrospective analysis was performed in the period between January 2019 and January 2021 for patients underwent PCNL for renal stones 2 cm or more. They were 77 patients divided into two groups, group (A) prone 38 patients and group (B) supine 39 patients.

Results: the study demonstrated a significant difference in operation time which was (92.5 ± 24.85 min.) in prone group & (68.3 ± 22.90 min.) in supine group with p-value (<0.001), also significant difference in fluoroscopy time which was (258.0 ± 57.19 sec.) in prone group & (166.9 ± 46.60 sec.) in supine group with p-value (<0.001) with shorter operation and fluoroscopy time in the supine than the prone. The study has also demonstrated that there is no statistically significant difference between the two groups as regarding to stone free rate

Conclusion: in patients with renal stones, 2 cm or more, supine PCNL has proved to be superior to prone PCNL as regarding operative and fluoroscopy time but no difference as regards stone free rate. However, Urologists should be familiar with the differences in the positions and be able to use the method appropriate for each patient.

Keywords: Percutaneous nephrolithotomy, Supine, Prone, Renal stones

1 INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is the treatment of choice for renal stones ≥ 2 centimeters (cm) [1]**.** Following the first description of percutaneous renal access with a patient in the prone position by Goodwin et al.[2] **.**Fernstrom and Johansson reported the first case of stone extraction through a nephrostomy tract in 1976 [3].

The traditional prone position for PCNL is favored by a majority of urologists due to familiarity with the procedure, larger surface area for choice of puncture site, a potentially more direct approach to the kidney, have no limits for instruments manipulation and allow simple introduction of multiple accesses [4].

However, the prone position is associated with several anesthetic and surgical disadvantages. It is contraindicated in morbidly obese patients and with certain

respiratory diseases or skeletal deformities [5].Ventilation difficulties may occur in prone position and control of the airways by anesthesiologist is more demanding [6].

Valdivia-Uria and associates first described the lateral access with the patient in supine position in 1987. Based on their CT studies, they suggested that supine position has several advantages, including that the colon floats away from the kidney when the patient is in supine position, ease of patient positioning, more patient comfort, dependent Amplatz sheath drainage and better control of the airway during procedure [7].

Additionally the supine position provides reduced cardiovascular or ventilator dysfunction, less operative time, less X-ray exposure and the surgeon can comfortably sit during the operation [8].

In supine position the Amplatz sheath is oriented downward, maintaining low pressure in the renal pelvis reducing the risk of fluid absorption, facilitating spontaneous stone fragment evacuation and limiting stone dislocation to calyces or to the ureter. Unfortunately, this collapses the pelvicalyceal cavity and hence may reduce the vision [9].

The modified supine position that combines a tilted supine position with lithotomy provides the additional benefit of allowing simultaneous retrograde access to the upper tracts. This enables a dual approach to large staghorn calculi and ureteric stones potentially reducing the operative time, trauma to the patient and increasing the stone free rate [9].

2 AIM OF THE WORK

The aim of this work is to compare between supine and prone PCNL in the management of renal stones regarding stone free rate, operative time and fluoroscopy time.

3 MATERIALS AND METHODS

3.1 Study Design

This is a comparative study with a retrospective analysis of performed Patients underwent PCNL for the period between January 2019 and January 2021.

3.2 Study Population

Seventy seven patients having renal stones more than 2 cm underwent PCNL starting from January 2019 till January 2021 in Tanta University hospital. Patients were divided into two groups. Group A: included 38 patients subjected to PCNL in the prone position Group B: included 39 patients subjected to PCNL in the supine position according to Valdivia Uria et al [10] or modified supine position according to Galdako et al [11].

3.3 Study methods:

3.3.1 Preoperative evaluation:

Age, gender and body mass index (BMI) of patients were recorded. Stone site, size and Hounsfield unit (HU) also were reported according to Non contrast multi-slice computed tomography (CT) scan of abdomen and pelvis.

3.3.2 Operative Procedure:

The procedure was performed under general anesthesia. In the first group, patients were first positioned in lithotomy position for cystoscopy and ureteric catheter insertion then turned to prone position but In the second group, patients were adjusted in supine Valdivia position or one of its modifications. Using 22F rigid cystoscope, open tip ureteric catheter (6 French) was inserted. Retrograde instillation of contrast media for opacification of the collecting system was done via contrast injection through the ureteric catheterznd the needle was advanced through the calyceal fornix till urine was seen coming out of the needle after removal of its stellate. Insertion of the guide wire and dilatation of the tract over sequential Alken dilators then introducing of Amplatz sheath. The stones were disintegrated by ultrasonic lithotripter or pneumatic lithotripter and stone fragments were removed using graspers. At the end of procedure, 16 Fr. Foley's catheter was inserted in the tract over the guide wire and the balloon was inflated.

3.3.3 Criteria of evaluation:

Operative time in minutes (This was defined as the time interval between cystoscopy for ureteral catheter insertion till the placement of nephrostomy tube at the end of procedure), radiation (fluoroscopy) time in seconds and post-operative stone free rate (which defined as no residual stones or insignificant residual stone less than 4 mm in diameter) were compared between both groups.

3.4 Statistics

Data were collected and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were presented as number and percentages while quantitative data were presented as mean, standard deviations and ranges. The comparison between groups with qualitative data were done by using Chi-square test and/or Fisher exact test instead of chi-square test when the expected count found less than 5 in any cell. The comparison between two groups regarding qualitative data with parametric distribution was done by using Independent t-test. The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following: $P>0.05$: non-significant. $P<0.05$: Significant. $P< 0.01$: Highly significant.

4 RESULTS:

4.1 Patients' demographic data:

The mean age of studied patients was 41.0 ± 13.65 and 41.1 ± 12.87 years for group A and group B respectively. Group A included 21 males and 17 females but group B included 21 males and 18 females. The mean BMI of the studied patients was 26.8 ± 3.32 and 27.9 ± 3.9 (kg/m2) for group A and group B respectively. There was no statistically significant difference as regards patients' demographic data between both groups as shown in (Table 1).

Table (1): Demographic data in both studied groups

Variables	Prone PCNL (n = 38)	Supine PCNL (n=39)	Test of significance	P
Age (yr.)				
Min. – Max.	18 - 69	19 - 68	t	0.980
Mean ± SD.	41.0 ± 13.65	41.1 ± 12.78	0.025	
Gender				
Male	21 55.0%	21 54.0%	$\chi 2$	1.000
Female	17 45.0%	18 46.0%	0.000	
BMI				
Min. – Max.	20.7 – 37.4	21 – 39	U	
Mean ± SD.	26.8 ± 3.32	27.9 ± 3.9	730.000	0.500

4.2 Stone characteristics:

As regard stone location and number, Solitary renal pelvic stone was found in 19 and 23 patients in group A and group B respectively, solitary upper calyceal stone was found in 2 and 3 patients in group A and group B respectively, solitary middle calyceal stone was found in 4 and 2 patients in group A and group B respectively, solitary lower calyceal stone was found in 9 patients in group A and 8 patients in group B respectively and multiple renal stones were found in 4 and 3 patients in group A and group B respectively. In group A; the stones were right sided in 22 patients and left sided in 18 patients but in group B; the stones were right sided in 20 patients and left sided in 20 patients. In group A; the size of treated stones ranged from 17.0 – 42.0 mm with a mean of 26.4 ± 4.76. In group B; the size of treated stones ranged from 20 – 39 with a mean of 25.3 ± 4.06.The Hounsfield unit (HU) of renal stones in group A ranged from 572 to 1536 (mean= 990.5 ± 294.25) and in group B it ranged from 390 to 1588 (mean= 897.2 ± 367.29). There was no statistically significant difference between prone position and supine position regarding stone site, size, side, and Hounsfield unit as shown in (Table 2).

Table (2): Stone characteristics in both studied groups

Variables	Prone PCNL (n = 38)	Supine PCNL (n=39)	Test of significance	P
Site				
Renal pelvis	19 (50.0%)	23 (59.0%)		
Upper cx.	2 (5.5%)	3 (7.5%)	MC	
Middle cx.	4 (10.5%)	2 (5.5%)	1.685	0.821
Lower cx.	9 (23.5%)	8 (20.5%)		
Multiple	4 (10.5%)	3 (7.5%)		
Size (mm)	17 – 42	20 – 39		
Min. – Max.	26.4 ± 4.76	25.3 ± 4.06	U	
Mean ± SD.	26.5 (5)	25.0 (4.750)	688.000	0.279
Median (IQR)				
Side				
Right	22 (55%)	20 (50.0%)	$\chi 2$	0.654
Left	18 (45%)	20 (50.0%)	0.201	
Density (HU)				
Min. – Max.	572 - 1536	390 – 1588	U	
Mean ± SD.	990.5 ± 294.25	897.2 ± 367.29	669.000	0.207
Median (IQR)	1042 (573.75)	911.5 (659)		

4.3 Intraoperative data:

The operative time was measured starting from cystoscopy and ureteric catheter insertion until nephrostomy tube insertion. In group A, the mean operative time was 92.5 ± 24.85 minutes while in group B it was 68.3 ± 22.9 minutes with a statistically significant difference ($p<0.001$) (Table 3). In group A, the fluoroscopy time ranged from 156 to 351 seconds and the mean was 258.0 ± 57.19. In group B, the fluoroscopy time ranged from 103 to 259 seconds and the mean was 166.9 ± 46.6 with a statistically significant difference ($p<0.001$) (Table 3).

Table (3): Intraoperative data

Variables	Prone PCNL (n = 38)	Supine PCNL (n=39)	Test of significance	P
Operative time (min.)				
Min. – Max.	49 – 129	30 – 108	t	<0.001
Mean ± SD.	92.5 ± 24.85	68.3 ± 22.90	4.529	
Median (IQR)	94.0 (42.25)	70.0 (40.250)		
Fluro time (sec.)				

Min. – Max. Mean ± SD. Median (IQR)	156 - 351 258.0 ± 57.19 260.0 (108.75)	103 – 259 166.9 ± 46.60 165.0 (91.5)	U 194.000	<0.001

4.4 Stone free rate:

Initial stone free rate (on first day postoperative) was 84.2 % (32/38) and 89.7% (35/39) in group A and group B respectively (p-value =0.210). Six patients in group A and four in group B required auxiliary procedures. In group A, residual stones (>4mm) were treated with ESWL in 4 patients and 2nd look PCNL in 2 patients. In group B, residual stones (>4mm) were treated with ESWL in 3 patients and 2nd look PCNL in one patient (Table 4).Final stone free rate (1 month postoperative and after single auxiliary procedure was 92.1% (35/38) and 94.87% (37/39) in group A and group B respectively (Table 4). There was no significant difference between both groups.

Table (4): Stone free rate

Variables	**Prone PCNL (n = 38)**	**Supine PCNL (n=39)**	**Test of significance**	**P**
Initial stone free rate Yes No	32 (84.2 %) 6 (15.8%)	35 (89.7 %) 4 (10.3%)	$\chi 2$ 1.569	0.210
Final stone free rate Yes No	35 (92.1%) 3 (7.9%)	37 (94.87%) 2 (5.13%)	FE 0.734	0.675

5 DISCUSSION:

The standard treatment of renal stones more than 2 cm is PCNL which widely replaced open stone surgery since its first description by Fernstrom and Johansson [12].However, the prone position is associated with several anesthetic, surgical and logistical disadvantages. It is difficult in morbidly obese patients and with certain respiratory diseases or skeletal deformities [5]. Ventilation difficulties may occur in prone position and control of the airways by anesthesiologist is more demanding [6].

The supine position for percutaneous stone surgery was first described by Valdivia-Uria et al. [13]. Many authors suggested this position as being more safe and easy with many advantages over the prone position in terms of reducing operation time, avoiding injuries that may occur during repositioning the patient, anesthesia-related difficulties, as well as

reducing radiation exposure to the team, and ability of the surgeon to perform the procedure whilst sitting [14].

Furthermore, supine PCNL reduces the risk of fluid absorption and allows spontaneous washout of fragments [15]. However, one of the main disadvantages of the supine position is the little enough space for more punctures when needed [16].

In our study, we retrospectively compare the outcome between supine position with conventional prone position for renal stone 2cm or more. The procedure was done by the same team of urologists expertise in supine and prone PCNL and were evaluated in term of operative time, fluoroscopy and stone free rate.

Patients included in the current study were randomly divided into two equal groups: Group A: included 38 patients subjected to PCNL in the prone position. Group B: included 39 patients subjected to PCNL in the supine position.

In the current study, there was no statistically significant difference between prone position and supine position in PNCL regarding age, sex, BMI, size of stone and Hounsfield unit which indicated a good matching between the two groups. These results agreed with a prospective randomized trial conducted by Wang et al., [17] who compared the efficacy and safety of PCNL in the prone and modified supine positions and they found that there were no significant differences between both groups as regards the numbers of patients, sex distribution, age, BMI and stone criteria.

The mean BMI of the patients in our study was 26.8 ± 3.32 and 27.9 ± 3.9 (kg/m2) for prone PCNL and supine PCNL groups respectively. Bagrodia et al. [18] evaluated the impact of BMI on clinical outcomes and the associated costs with PCNL. They found no significant differences among groups with regard to stone-free rate and complication rate, operative time, length of hospital stay, or need for multiple accesses. In the same way, Pearle et al., [19] El Assmy et al., [20] found insignificant differences in the outcomes between obese and nonobese patients. The outcome of PCNL in their study was independent on patient BMI. However supine PCNL offers the potential advantages of less patient handling, only draping the patient once, and easier access to the urethra, allows better airway management and may be less hazardous, especially for morbid obesity, and preferrd by anesthesiologists. There is better drainage with the Amplatz sheath, and stone fragment evacuation is facilitated [21].

There was no significant difference between both groups as regard the stone site, size and Hounsfield unit. About 75.0% of our patients had stones in renal pelvis and lower calyx in prone position group. Whereas, in supine position group, 80.0% of patients had their stones in the renal pelvis and lower calyx as the most common site. While, upper calyx and middle calyx recorded the lowest percent in both groups. Paksi et al., [22] also

recorded that the most common site of stone was in renal pelvis and lower calyx, 72.1 % and 78.6% in prone and supine position respectively.

The stone size ranged from 17 to 42 mm with a mean of 26.4± 4.76mm in the prone group and from 20 to 39 mm with a mean of 25.3±4.06mm in the supine group and all were single stones except for 4 patients in group A and 3 patients in group B were multiple calyceal stones with non-significant difference. Abd Elgawad et al., [23] found that stone size in prone position patients ranged from 24 mm to 40 mm, all were single stones, 10 were in renal pelvis while 5 were in lower calyx. On the other side, stone size in supine position patients ranged from 22 mm to 45mm, 11 were single renal stones, and 4 were multiple renal stones located in renal pelvis & lower calyx, renal pelvis & middle calyx, twice in lower calyx, twice in renal pelvis. With no statistically significant difference regarding size and site of the stones.

Jones et al., [24] studied supine and prone PCNL on 236 patients. The supine group patients were 160. The types of stones were multiple stones (49 patients), staghorn stones (17 patients), and stones more than 2 cm (94 patients). While the prone group patients were 76, the types of stones were multiple stones (18 patients) and staghorn stones (15 patients), stones more than 2 cm (43 patients). We excluded complex staghorn stones from our study.

Also, Eliwa et al., [25] studied supine and prone PCNL on 60 patients with staghorn stones and stones more than 2 cm in size. In prone group the stone size was more than 2 cm (25 patients) and 5 patients with staghorn stones and in the supine group stone size was more than 2 cm (28 patients) and 2 patients with staghorn stone. Whereas, Sohail et al., [26] demonstrated that the stone size was in range of 29 mm in prone group (101 patients) and 29.7 mm in supine group (96 patients).

In the current study, the operative time was shorter in the supine group (mean 68.3 ± 22.90 min) than in the prone group (mean 92.5 ± 24.85 min) with statistically significant difference between both groups ($p<0.001$). Our results were similar to Sohail et al., [26] who found a shorter operative time in the supine group compared with the prone group.

Valdivia et al., [27] reported shorter operative time in the prone than in the supine group (87.7 versus 90.1 min), but the difference between them did not reach a significant difference. Also Giusti et al., [28] reported that the mean time between the first kidney puncture and the creation of a valid access was longer in supine group than that in prone group but with no statistical significance which disagree with our results.

We attributed this mainly to many factors such as different characteristics of stones, instruments, or techniques, as well as different definition of operative time among included studies and may be due to that they were more familiar with prone position. Apparently, PCNL in the prone position was thought to require a longer time, since

patients required to roll to the prone position after ureteral catheterization and to roll back to the supine position after surgery. We calculated the operative time starting from the patient positioning for fixing ureteral catheter till the fixation of the nephrostomy tube. In the supine position, the small stone fragments and dust created by fragmentation usually flows out while the fragmentation is in progress while in the prone position, these small fragments tend to migrate to remote calyces, increasing operative time.

One of the significant risks of percutaneous stone surgery is the risk of radiation exposure, both to patient, surgeon, and theater staff. In the current study, the mean fluoroscopy time was 258.0 ± 57.19 sec in the prone group and 166.9 ± 46.60 sec in the supine group, with statistically significant difference between prone and supine positions ($p<0.001$).

Our results are in accordance agreement with Erbin et al.,**[29]** who compared the outcomes of supine and prone mini-PCNL in the treatment of renal stones and found that fluoroscopy time in supine mini-PCNL was significantly shorter than prone mini-PCNL group (180 ±102 sec vs. 294±270 sec, $p=0.001$).

Abdel-Mohsen et al., [30] in contrast to our results, compared the technical aspects, operative time, safety and effectiveness of PCNL in the supine position vs. the standard prone position. They found no significant difference between the studied groups as regards fluoroscopy time and patients outcome.

Notably, it would be likely to neglect the difference of time spent on some exactly procedures, such as trials for establishing the access or due to anteromedial displacement of the kidney during tract dilatation in supine position which is less in obese patients and can be overcome by abdominal compression.

An important benefit of the supine position over the prone position is the potentially reduced radiation exposure. As the puncture site is more lateral with supine PCNL, the surgeon's hands are further away from the fluoroscopic X-ray tube and are exposed to less radiation and surgeon's chest in sitting position is far of the X-ray beam.

In the current study, residual stones were detected among 6 patients (15.8%) in prone position and 4 patients (10.3%) in supine position, which was insignificant ($p=0.21$).

Similar to our findings, Abd Elgawad et al., [23] found that residual stones in prone position was found in 4 patients (26.7%), higher than residual in supine position which was found in 2 patients (13.3%). Jones et al., [24] stated that there was a high prevalence in stone free rate for the supine position than for the prone (70% supine vs. 50% prone, $p=0.005$).

Also, Sohail et al., [26] demonstrated that 79.2 % of patients were stone free in the prone group and 85 % of patients were stone free in the supine group with no significant difference between the two groups.

In addition, Wang et al., [17] found that there was a statistically significant difference between supine and prone group PCNL p-value = 0.03, with lower stone clearance for supine group (73.3%) versus (88.7%) for prone group, but they stated that because they compared only the stone size in the study not complexity of the renal stones.

Contrary to our results, a meta-analysis done by Yuan et al., [31] found that the stone-free rate in the supine group was 74.3% (1266/1703) and the rate for the prone group was 77.7% (4025/5178).This meta-analysis demonstrated that PCNL in the prone position was better than supine position for the stone-free rate. This was in accordance with Zhang et al.,[32] **.**The reasons for the higher stone-free rate in prone position might be due to the wider choice for the renal puncture site and more space for the manipulation of the nephroscope. In addition, in the supine position it is more challenging to follow the migratory stones. Zhang et al. suggested that the difference in results could be a result of a larger number of studies included in their analysis and the heterogeneity in the stone-free assessment of studies.

The present study showed that, 6 patients of prone position patients had auxiliary procedures versus 4 patients in supine position patients. Shock wave lithotripsy was the most common procedure used among the studied patients, followed by secondary look PCNL.

In the study by Abd Elgawad et al., [23] as regard the need for auxiliary treatment, there was no need for second look PCNL for both groups of the study, 4 patients in prone group required postoperative ESWL for their residual stones, two of them were non stented, and two were stented using JJ stents, one of them was intraoperative stent, and the other was fixed for postoperative urinary leakage which was only one case of leakage in this group of patients. On the other hand only two patients in supine group required ESWL, one of them was stented intra operative and, the other was non stented.

6 Conclusions:

Treatment of renal stones ≥ 2cm by PCNL in either prone or supine position is effective and safe. This study demonstrated statistically significant shorter operative time and fluoroscopy time in favour of supine position but stone free rate is similar in both position. PCNL in supine position is more comfortable for anesthesia team. More studies are needed with larger population to evaluate which position is better in PCNL.

Ethical Approval:

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

Consent

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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