ORIGINAL RESEARCH

Comparative Study of Supine Versus Prone Percutaneous Nephrolithotomy for Renal Calculi: A Retrospective 5-year Single Center Experience

Glenys Mae Doria, MD; Karl Marvin M. Tan, MD, FPUA; Eli Paulino F. Madrona, MD, FPUA and Michael Eufemio L. Macalalag, MD, FPUA

Department of Urology, Veterans Memorial Medical Center

Objectives: To describe the demographics of patients undergoing supine PCNL (s-PCNL) and prone PCNL (p-PCNL) at Veterans Memorial Medical Center (VMMC) and to compare different data collected between the two approaches.
Methods: Retrospective data collection was done through chart review of patients who underwent supine and prone PCNL at VMMC from 2018 to 2022. Information collected includes patient demographics, clinical profile, stone burden and laterality, surgical technique, hospital days, complications and management.
Results: A total of 176 cases, 132 s-PCNL and 44 p-PCNL, were included. Demographic data show no statistical difference as to age and sex. There is no statistical difference in the stone burden, stone density, and Guy's stone scores between the two groups. There was no statistical difference in the mean operative time and stone free rates between the two groups. Mean hospital stay was 6.11 days for s-PCNL and 6.76 for p-PCNL, with significant statistical difference in favor of s-PCNL. Complication rates were 15.2% for supine PCNL and 13.6% for prone PCNL. There was no statistical significant difference in Clavien-Dindo complications between the two groups. There was no mortality reported for both groups
Conclusion: There is an observed increasing trend in the number of supine PCNL versus prone PCNL from 2018 to 2022. Supine PCNL is as effective and safe as prone PCNL. Supine PCNL appears to be more beneficial in terms of hospital stay in days. However, one limitation of the study its being retrospective and collated data which is the cause of the discrepancy in sample population size between the two groups.

Key words: Supine percutaneous nephrolithotomy (PCNL), prone PCNL, renal calculi

Introduction

Stone surgery comprises 36% of the urologic surgical cases at VMMC. Percutaneous nephrolithotomy has been increasingly used in this institution to address renal calculi. The procedure involves percutaneous renal puncture, dilation of the tract, and fragmentation and clearance of calculi.[1] PCNL is now considered as the standard management for large and complex stones.[2,3] Its indications have continued to broaden, further stressing the importance of percutaneous nephrolithotomy in the skill set of urologists.

The goal of renal stone surgery is to ensure stone clearance while minimizing complications.[4] Hence, the determination of stone-free and complication rates and the factors and practices that affect them is essential to ascertain achievement of success in percutaneous nephrolithotomy. Use of stone scoring systems, development of new technology, modification of surgical techniques, and accumulation of experience and training are some of the means used to ensure optimal outcomes.

This study describes the profile of patients undergoing PCNL in one tertiary level hospital. The investigators describe the stone-free rates, perioperative complications, and outcomes of percutaneous nephrolithotomy and compare these variables between supine and prone PCNL.

Methods

The investigators conducted a descriptive retrospective cohort study on patients who underwent percutaneous nephrolithotomy at VMMC from 2018 to 2022. Charts were secured from the medical records/medical library for data collection.

Inclusion Criteria

Included were patients of all ages, with nephrolithiasis and who underwent percutaneous nephrolithotomy, done by Urology residents and consultants at VMMC from years 2018 to 2022.

Exclusion Criteria

Excluded were pregnant patients and patients whose charts have incomplete history, physical examination findings, imaging results, and laboratory results.

The patient demographics and clinical profile were collected. They included patient's age, gender, body mass index, preoperative hemoglobin, preoperative creatinine, urine culture, and preoperative white blood cell count. Information on stone characteristics including laterality, Guy's stone score, stone location, attenuation or stone density, presence of structural malformation, and preoperative and postoperative imaging done were gathered. Sample size computation was done using the software StatCalc from EpiInfo 7.1.4.0. Estimation was based on the assumptions that: 1) the ratio of patients without the ipsilateral open renal stone surgery is 1; 2) 95% of patients with ipsilateral open renal stone surgery are stone free; 3) 5% of patients without ipsilateral open renal stone surgery is stone free. In a computation of odds ratio (OR)=2.80 (Atmoko, et al., 2016) having stone free rate carried out at 95% confidence level, a sample size of 180 patients will have 80% power of rejecting the null hypothesis if the alternative holds.

Upon securing medical risk assessment and informed consent for the procedure, the patient would then undergo percutaneous nephrolithotomy. Surgical technique was described through data on intraoperative imaging used, position, intraoperative antibiotic given, energy device used for stone fragmentation, number of PCNL access established, nephrostomy tube usage, and double J stent usage.

Perioperative data considered were the surgeon's experience, stone clearance/stone free status, operative time, presence of complications and management done, total number of hospital days, and intraoperative blood transfusion.

All categorical data were encoded by assigning alphanumeric codes for an efficient encoding process making sure that each code can easily be traced back to its original category. A master list was prepared to ensure easy referencing process. The numerical information such as age, hospital stay and other demographic and clinical characteristics were encoded as it is up to 2 decimal places to ensure accuracy.

To describe the demographic profile of the patients, stone characteristics, surgical techniques, residual stones and supine and prone PCNL complications made use of descriptive statistics. Mean and standard deviation were used for describing continuous data (at least interval scale) while frequency and percent were used for datasets with categorical characteristics (nominal data). Frequency distribution tables were used to present the summary of the data sets. For the comparison of the means between two groups, t-test for two independent means was used. T-test for two proportions was used for the comparison of the difference in the percentages. All data were coded and analyzed using R software.

Results

Table 1 shows the demographic profile of 176 patients who underwent percutaneous

Table 1. Patient demographics.

Total Subjects	Supine	Prone	
	n=132	n=44	P-value
Mean age (in years)	55.34±13.307	56.67±11.37	0.260
Sex			
Male	81 (61.4%)	21(47.7%)	0.056
Female	52 (39.4%)	23(52.3%)	0.067
Mean BMI	25.24±3.12	24.48±3.5	0.101
Mean WBC	8.17±3.23	8.53±2.66	<0.01
Mean Hemoglobin	135±16.106	147.73±134.32	0.265
Antibiotics			
Amikacin	1 (0.8%)	0(0%)	0.281
Cefoxitin	6 (4.5%)	3 (6.8%)	0.277
Ceftazidime	2 (1.5%)	0(0%)	0.206
Ceftriaxone	117(88.6%)	38 (86.4%)	0.344
Ertapenem	1 (0.8%)	0 (0%)	0.281
Levofloxacin	2 (1.5%)	0 (0%)	0.206
Meropenem	2 (1.5%)	0 (0%)	0.206
Piperacillin Tazobactam	1 (0.8%)	3 (6.8%)	<0.01

nephrolithotomy. The mean age of patients was 55.34 years for those who underwent s-PCNL and 56.67 years for those who underwent p-PCNL. More males underwent s-PCNL at 61.4% while more females underwent p-PCNL at 52.3%. The mean BMI of patients who underwent s-PCNL was 25.24, higher than mean BMI of patients who underwent p-PCNL at 24.48. The mean WBC count was 8.17 in those who underwent s-PCNL and 8.53 in the p-PCNL group. Mean preoperative hemoglobin was 135 in s-PCNL and 147.73 in p-PCNL.

Preoperative antibiotics were given to patients as routine practice. In both groups, Ceftriaxone was most commonly given to patients at 88.6% in s-PCNL and 86.4% in p-PCNL, followed by Cefoxitin at 4.5% and 6.8%, respectively. Other antibiotics given to the rest of the patients were Amikacin, Ceftazidime, Ertapenem, Levofloxacin, Meropenem, and Piperacillin Tazobactam.

Table 2 shows that all patients had a plain CT stonogram done preoperatively. In terms of laterality, in the s-PCNL group, 37.9% had stone on the right and the other 62.9% on the left. For p-PCNL, 61.4% had stone on the right and 38.6% on the left.

On grading using the Guy's stone score, for s-PCNL the most frequent was Grade I at 41.7% followed by grade IV at 27.3%, grade II at 20.5%, and grade 10.6%. In the p-PCNL group, the most frequent was grade II at 29.5%, followed by grade III and IV both with 22.7% and grade I at 25%.

The mean stone burden for s-PCNL was 3.18cm and for p-PCNL is 3.17cm at 3.2cm and the mean stone density found in s-PCNL was 1067.43 and 1069.06 in p-PCNL.

Table 2. Stone characteristics.

	Supine	Prone	p-value
Laterality			
Right	50 (37.9%)	27 (61.4%)	<0.01
Left	83 (62.9%)	17 (38.6%)	<0.01
Guy's stone score			
Grade I	55 (41.7%)	11 (25%)	0.024
Grade II	27 (20.5%)	13 (29.5%)	0.106
Grade III	14 (10.6%)	10 (22.7%)	0.021
Grade IV	36 (27.3%)	10 (22.7%)	0.276
Mean stone burden (in cm)	3.18±1.273	3.17±1.4	0.495
Mean stone density (in Hounsfield units)	1067.43±336.109	1069.06±356.47	0.489
Anatomic abnormality	5(3.8%)	1(2.3%)	0.468
Preoperative imaging			
CT scan	132(100%)	44(100%)	-

On review of imaging and intraoperative findings, the noted structural malformations among patients who underwent s-PCNL were bladder neck stenosis, bifid renal pelvis, narrow infundibulum at superior pole, ureteropelvic junction stenosis, and ureteral stenosis, and in p-PCNL was ureteral stenosis, all with an incidence of 1 each.

Table 3 shows the techniques used in the conduct of PCNL and outcomes. General endotracheal anesthesia (GETA) was used for all cases of p-PCNL. On the other hand, there was a variety of anesthesia utilized for s-PCNL: 92.4% (122 of 132) GETA, 5.3% (7 cases) under Spinal Anesthesia, 0.8% (1 case) under Epidural (continuous lumbar epidural block) and 1.5 (2 cases) utilizing combined technique of GETA with epidural anesthesia.

A majority in both groups utilized fluoroscopy (125 of 132 for s-PCNL and 39 of 44 for p-PCNL). The remaining minority were accessed with sonographic guidance. Majority of the cases were accessed with a single access point except for 2 cases of multiple access points for complete stone fragmentation in the supine PCNL group.

Intraoperative intravenous gentamicin was given in 92.4% of s-PCNL group and in 93.2% of the p-PCNL group. In the remaining cases, only a grasper was used to evacuate the stone without any fragmentation done. Some surgeons opted not to administer intraoperative antibiotics.

Pneumatic lithotripters were utilized in 97% for s-PCNL and in 88.6% of the cases for p-PCNL. The rest and minority of cases were fragmented with ultrasound lithotripsy. Majority of the cases were accessed with a single access point except for 2 cases of multiple access points for complete stone clearance in the supine PCNL group.

In the p-PCNL group, all were accessed through a superior calyx however, in s-PCNL, 92.4% were accessed through an inferior calyx, 4.5% in a middle calyx, and 3% in a superior calyx. All cases for supine PCNL and prone PCNL had intra-operative

Table 3. Surgical technique and outcomes.

	Supine	Prone	P-value
Anesthesia			
GETA	122 (92.4%)	44 (100%)	0.030
Spinal	7 (5.3%)	0 (0%)	0.060
Epidural	1 (0.8%)	0 (0%)	0.281
GETA-epidural	2 (1.5%)	0 (0%)	0.206
Intraoperative Image Guidance			
Fluoroscopy	125 (94.7%)	39 (88.6%)	0.084
Ultrasound	7 (5.3%)	4 (9.1%)	0.184
Combined	0 (0%)	1 (2.3%)	0.041
Intraoperative Gentamicin			
Yes	122 (92.4%)	41 (93.2%)	0.434
No	10 (7.6%)	3 (6.8%)	0.434
Energy			
Pneumatic Lithotripsy	128 (97%)	39 (88.6%)	0.015
Ultrasonic Lithotripsy	4 (3%)	5 (11.4%)	0.015
Access			
1	130 (98.48%)	44 (100%)	
>1	2 (1.52%)		
Calyx			
Superior	4 (3%)	44 (100%)	<0.01
Middle	6 (4.5%)	0 (0%)	0.075
Inferior	122 (92.4%)	0 (0%)	<0.01
NT usage	132 (100%)	44 (100%)	-
DJ stent usage	132 (100%)	44 (100%)	0.281
Surgeon's experience			
Competent (has done more than 60 cases)	6 (4.5%)	6 (13.6%)	0.019
Trainee (has done 60 cases or less)	126 (95.5%)	38 (86.4%)	0.019
Stone free			
Yes	122 (92.4%)	42 (95.5%)	0.245
No	10 (7.6%)	2 (4.5%)	0.245
Mean operative time	106.77±47.066	98.23±54.12	0.175
Complications			
None	112 (84.8%)	38 (86.4%)	0.403
Yes	20 (15.2%)	6 (13.6%)	0.403
Clavien-Dindo Complication Category			
Grade I	4 (3%)	2 (4.5%)	0.316
Grade II	11 (8.3%)	3 (6.8%)	0.374
Grade IIIa	1 (0.8%)	0 (0%)	0.281
Grade IIIb	2 (1.5%)	0 (0%)	0.206
Mean hospital days	6.11±1.603	6.76±2.26	0.040
Intraoperative blood transfusion			
Yes	41 (31.1%)	15 (34.1%)	0.354
No	91 (68.9%)	29 (65.9%)	0.354
Postoperative Imaging			
plain KUB film	132 (100%)	44 (100%)	0.030

double J stent insertion and nephrostomy tube placement.

Most cases were done by trainees at 95.5% in s-PCNL and 86.4% of p-PCNL while the rest were done by competent surgeons.

Stone clearance was achieved in 92.4% of s-PCNL cases and in 95.5% of p-PCNL cases, which shows no significant statistical disparity (p=0.245). Stone clearance was determined intraoperatively by the surgeon and through the postoperative plain KUB film that all patients underwent. Mean operative time was 106.37 mins + 47.06 for s-PCNL and 98.23 mins ±54.12 for p-PCNL with no statistical difference between the two.

Uneventful post-operative course was noted in 112 of 132 (84.8%) for s-PCNL and 38 of 44 (86.4%) for p-PCNL. The remaining had post-operative complications and were categorized as Clavien I (s-PCNL-4 cases and p-PCNL-2 cases), II (s-PCNL-11 cases and p-PCNL-3 cases), IIIa (s-PCNL-1 cases and p-PCNL-0 cases), IIIB (s-PCNL-2 cases and p-PCNL-0 cases) and IV (s-PCNL-2 cases and p-PCNL-1 cases). No Clavien Dindo V were noted. Intraoperatively, blood transfusion was done in 31.1% (41 of 132) of supine PCNL and 34.1% (15 of 44) prone PCNL case with no significant statistical difference with p-value 0.354. Mean hospital stay was 6.11 days + 1.6 for s-PCNL and 6.76 + 2.2 days for p-PCNL, significantly shorter for the s-PCNL group.

Table 4 shows the occurrence of residual stones according to the preoperative Guy's Stone Score. Of the 12 patients who had residual stones, 5 had grade IV GSS (s-PCNL-4, p-PCNL-1), 3 had grade III GSS (s-PCNL-2, p-PCNL-1), 3 had grade II GSS, while 1 had grade I GSS. This shows the usefulness of the Guy's Stone Score in predicting probability of stone clearance in patients who undergo PCNL.

There were a total of 18 cases of supine PCNL that had complications. Shock was addressed with norepinephrine and fluid challenge. Cases of anemia were treated with blood transfusion. 1 patient had cardiogenic shock which necessitated SICU admission and administration of norepinephrine and dobutamine. Cases of bleeding and hematuria were managed with IV tranexamic acid. Urosepsis was treated with culture-guided antibiotics and paracetamol. Colonic perforation that was recognised postoperatively was managed with emergency exploratory laparatomy and colostomy. DJ stent insertion was done in a case where leak per NT insertion site was noted.

Six of the 44 prone PCNL cases had complications. Hyperglycemia and increased creatinine were managed with hydration. Hematuria was managed with tranexamic acid. Cases with fever and sepsis were managed with antibiotics and antipyretics. A case of anemia required blood transfusion. 1 case had bradycardia for which atropine was given and blood transfusion done.

The data suggest that both procedures carry similar risks and the management strategies are consistent between the two. The outcomes of this study is comparable with those reported in

Table 4. Residual stone according to preoperative Guy's Stone Score (GSS)

Guy's Stone	Residual stones		
	SUPINE n=10	PRONE n=2	p-value
I	1(0.8%)	0(0%)	0.320
II	3(2.3%)	0(0%)	0.410
III	2(1.5%)	1(2.3%)	0.470
IV	4(3%)	1(2.3%)	0.430

literature, most notably in the, Clinical Research of the Endourological Society (CROES) with the most common complications being transient fever and bleeding.5 Other major complications encountered are sepsis and colonic perforation, which were managed with antibiotic administration and exploratory laparotomy with colostomy creation, respectively.

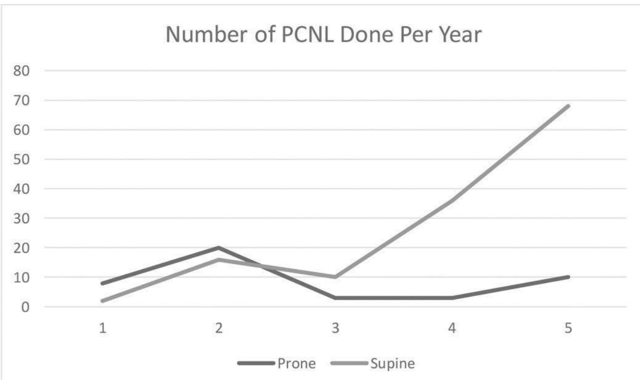

Figure 1. Number of PCNL done per year.

Figure 1 shows the number of PCNL done per year. Horizontal axis coincides with years covered by the study: 1 is 2018, 2 is 2019, 3 is 2020, 4 is 2021, and 5 is 2022. The graph demonstrates the increasing trend in the conduct of supine PCNL in the institution compared with prone PCNL.

Discussion

The worldwide prevalence rate of kidney stone disease ranges from 1 to 20%.[6] There has been a noted rise in prevalence over the past years globally, which possibly includes those incidentally found on imaging done for other indications. There are various approaches employed to treat nephrolithiasis including medical dissolution therapy, extracorporeal shockwave lithotripsy, open surgeries, and endourologic procedures such as retrograde intrarenal surgery and percutaneous nephrolithotomy.

Both the American Urological Association and the European Association of Urology recommend percutaneous nephrolithotomy as the first line management for nephrolithiasis 2cm and greater.[2,3] The technique of PCNL is continuously evolving in many aspects including diameter of instruments, patient positioning, tract creation techniques, lithotripters, and imaging modalities used, with the ultimate goal of stone clearance while minimizing complications.

This research study aimed to describe the experience of a high-volume tertiary level hospital with Percutaneous Nephrolithotomy for the treatment of nephrolithiasis in the supine and prone positions. This study found a high stone free rate with the use of PCNL, emphasizing the efficiency of the procedure with stone clearance. Most of those with residual stones are the patients who had staghorn or partial staghorn stones and this reflects what was already described in earlier studies on PCNL that stone burden is the most influential predictor of stone-free rate.[5]

Most of the procedures done in this institution were guided by fluoroscopy, in supine position, and using general endotracheal anesthesia. There is increasing interest in the use of ultrasound alone or in combination with fluoroscopy to reduce perioperative radiation exposure of the surgical team and the patient. In cases where spinal or epidural anesthesia was employed, the goal was to decrease blood loss because there was no expected systemic vasodilation, which was typically seen in general anesthesia.

The data here reflect a 31.8% rate of intraoperative blood transfusion and this was noted in larger stones, in longer operative times, and more commonly in procedures done by trainees. Infection is another commonly noted complication as seen in those who had transient fever, chills, and even septic shock. The data are in concordance with studies that have found bleeding, fever, and hematuria to be the most common complications of PCNL.[5]

Colonic perforation occurred in 2 of 176 patients (0.01%) and is one of the most significant complications of PCNL. In the literature, colon injury was noted to have a prevalence of 0.3% to 0.5%. Both occurrences were identified through passage of fecal material through the nephrostomy tract. The patients immediately underwent emergency exploratory laparotomy and creation of colostomy.

There is no statistical difference between supine and prone PCNL in terms of operative time, stone free rates, and complication rates. However, this study shows that supine PCNL is more advantageous in terms of hospital days. This study shows that supine PCNL is comparable to prone PCNL and its adoption in practice may be beneficial especially to the surgical team comfort which removes the task of repositioning the patient intraoperatively and results to shorter hospital stay of patients.

The limitations of this study are its retrospective nature and the smaller sample size of the prone PCNL group. Further prospective studies to include larger cohorts may be done in order to be able to detect associations among variables.

The technologies and techniques in PCNL have far evolved since it was first described in the 1970s. It has been established as efficient and produces favorable outcomes. Continuous development and studies are needed in order to further improve safety and efficacy.

References

1. Shin TS, Cho HJ, Hong SH, Lee JY, Kim SW & Hwang TK. Complications of percutaneous nephrolithotomy classified by the modified Clavien grading system: A single center's experience over 16 years. Korean J Urol 2011; 52(11): 769–75. https://doi.org/10.4111/kju.2011.52.11.769
2. EAU Guidelines: Urolithiasis | Uroweb. (n.d.). Retrieved September 24, 2020, from https://uroweb.org/guideline/urolithiasis/#note_186
3. American Urological Association. Kidney Stones: Surgical Management Guideline (n.d.). Retrieved September 24, 2020, from https://www.auanet.org/guidelines/kidney-stones-surgical-management-guideline
4. Leavitt D A, de la Rosette JJ & Hoenig DM. Strategies for nonmedical management of upper urinary tract calculi. In A. W. Partin, C. A. Peters, L. R. Kavoussi, R. R. Dmochowski, & A. J. Wein (Editors): Campbell-Walsh-Wein Urology 2020; 12th edition (p. 2069). Elsevier.
5. de la Rosette J, Assimos D, Desai M, et al. The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study: indications, complications, and outcomes in 5803 patients. J Endourol 2011; 25: 11-7.
6. Trinchieri A, Curhan G, Karlsen S, Jun WK. Epidemiology. In Stone Disease; Segura, J., Conort, P., Khoury, S., Eds.; ICUD: Paris, France, 2003; Distributed by Editions 21