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Supine Versus Prone: A Comparison of Percutaneous Nephrolithotomy Outcomes in Obese Patients

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Abstract

Introduction: Obesity increases both the incidence of nephrolithiasis and the technical challenges of percutaneous nephrolithotomy (PCNL). Evidence comparing supine and prone PCNL in obese patients remains scarce, with only one prior study worldwide. We compared peri-operative outcomes of the two positions in the largest Asian obese-specific cohort to date. **Methods:** We retrospectively reviewed all adults with body mass index > 30 kg/m^2 who underwent unilateral PCNL at Sarawak General Hospital and Sarawak Heart Centre between May 2020 and April 2023. Patients who had bilateral PCNL or concomitant procedures were excluded. Pre-operative non-contrast CT defined stone burden and Guy Stone Score; operative variables, outcomes and complications were extracted from the records and analysed. **Results:** A total of 124 patients were analysed (supine n = 79; prone n = 45). Baseline age, sex, BMI and ASA classification were similar, but the prone group harboured larger stones (mean surface area 11.04 vs 5.68 cm^2, $p < 0.001$) and more Guy stone score 4 cases. Mean operative time was significantly shorter in the supine position (96.9 ± 46.7 min) than in the prone position (159.6 ± 66.7 min; $p < 0.001$), the difference was most pronounced in Guy stone score 2 and 3 cases. This represents an approximate 63-minute operative time reduction with the supine approach. Stone-free rates (67.1% supine vs 68.9% prone; p = 0.837), overall treatment success (81% vs 73.3%; p = 0.319), transfusion (2.6% vs 8.9%; p = 0.113), complications (p = 0.134) and hospital stay (2.3 ± 1.6 vs 2.6 ± 1.9 days; p = 0.378) were similar. In Guy stone score 4 cases, the prone group showed a non-significant trend toward higher clearance. **Conclusion:** In obese patients, supine and prone PCNL provide equivalent safety and stone-clearance outcomes. Supine positioning offers a substantial operative-time advantage for low to moderate complexity stones, whereas the prone approach remains a viable option for very large or staghorn calculi when multiple tract access is anticipated.

Keywords

Percutaneous Nephrolithotomy, Obesity, Supine Position, Prone Position, Kidney Stones

1. Introduction

The increasing prevalence of obesity worldwide presents a significant challenge to various surgical procedures, necessitating a comprehensive understanding of the impact of obesity on surgical outcomes [1]. According to national statistics, the prevalence of obesity among the adult population in Malaysia is 20.1% [2]. Obesity is a well-established risk factor for the development of kidney stones, influenced by metabolic alterations, dietary habits, and lifestyle factors [3]-[6]. The adult population in Sarawak demonstrates a 4.04% prevalence of urinary stone disease [7].

The body mass index (BMI), a simple metric, is utilised to classify obesity and is calculated as the individual's weight in kilograms divided by the square of their height in meters. Individuals with a BMI exceeding 30 kg/m^2 are considered obese [8].

Percutaneous nephrolithotomy (PCNL) is the recommended treatment for patients with large, multiple, or complex renal calculi [9] [10]. PCNL has demonstrated the highest single-treatment stone-free rate in comparison to other treatment approaches for renal stones, such as extracorporeal shockwave lithotripsy (ESWL) [11] and retrograde intrarenal surgery (RIRS) [12]. A key concern with PCNL is the higher incidence and greater severity of complications compared to the other treatment modalities [13].

PCNL in obese patients may present distinct challenges owing to a variety of factors. These can include difficulties in patient positioning, suboptimal radiographic or ultrasonographic visualization during the procedure, and difficult access to the kidney due to the presence of excess fat tissue [14].

PCNL can be performed in either the prone or supine position. The prone approach provides more versatility for puncture access [15]. Traditionally, the prone position has been the preferred technique for PCNL. However, recent trends have shown growing interest in the supine PCNL approach. The potential advantages of the supine PCNL include eliminating the need for patient repositioning during the procedure, improved airway control and cardiovascular function management, and the opportunity for concurrent retrograde access to the collecting system [16] [17].

In addition, obesity introduces anatomical and physiological hurdles that may influence outcomes differently depending on patient positioning. Abundant subcutaneous and perirenal fat increases the skin-to-stone distance, displaces the kidney posterolaterally, and lengthens the access tract, thereby reducing fluoroscopic clarity and raising the risk of bleeding or tract loss [14]. From an anaesthetic standpoint, prone positioning in obese patients complicates airway management, whereas the supine position offers easier airway and haemodynamic control but can restrict craniocaudal instrument manoeuvrability and render upper-pole puncture more challenging [17]. These anatomic and ergonomic contrasts suggest that operative efficiency and complication profiles may vary with the choice of supine or prone PCNL in the obese population.

For obese patients, the existing body of research on this topic is limited, with only a single retrospective study examining the comparative outcomes of prone and supine PCNL [18].

This study is the first in Asia to examine and compare the outcomes of supine and prone PCNL performed on obese patients.

2. Methods

This retrospective study reviewed the records of all patients aged 18 years and older with a body mass index (BMI) exceeding 30 kg/m^2 who underwent PCNL at the Sarawak General Hospital and Sarawak Heart Centre during the period from May 2020 to April 2023. This study included only patients who underwent unilateral PCNL. Patients who had undergone bilateral PCNL or other concurrent procedures performed were excluded from the study.

The study was registered with the National Medical Research Register (NMRR) and approved by the Medical Research Ethics Committee (MREC).

Preoperative evaluation included non-contrast computed tomography (NCCT). The renal stones were evaluated and categorized according to the Guy stone score [19]. Laboratory tests comprised urine analysis and culture, serum creatinine, full blood count, and coagulation profile. Patients with infected urine culture received culture-specific antibiotics, and PCNL was performed once the culture became non-infective. The urologist determined the PCNL method (prone/supine) prior to the operation, based on their preference.

All PCNL procedures were conducted by the involvement of at least one experienced urologist.

Prior to surgery, the operating urologist examined each patient's pre-operative CT and identified the calyx whose access path was deemed most conducive to achieving complete stone clearance.

All patients gave informed consent prior to the operation as part of standard clinical practice. Preoperatively, all patients received prophylactic antibiotics and were administered general anaesthesia. For the supine PCNL procedure, patients were positioned in the Galdakao-modified supine Valdivia position, and a ureteric catheter was inserted under fluoroscopic guidance into the renal pelvis. A retrograde pyelogram was then performed to delineate the pelvicalyceal system. In the prone PCNL approach, patients were initially placed in the lithotomy position. A ureteric catheter was passed under fluoroscopic guidance to the renal pelvis, and a retrograde pyelogram was conducted to visualize the pelvicalyceal system. The patients were subsequently repositioned to the prone position.

Percutaneous renal access was achieved through either fluoroscopic guidance with a mobile C-arm (Philips Veradius Unity), ultrasound guidance with a BK5000 ultrasound system, or a combination of both techniques to access the most suitable calyx for complete stone clearance. After passing a 0.035-inch Roadrunner® guidewire into the pelvicalyceal system or ureter, the tract was dilated using sequential dilators to the size of 14Fr - 30Fr sheath. For smaller tract sizes (14/16Fr), a 12Fr miniaturized nephroscope was utilized, while a 22Fr standard nephroscope was used for larger tract sizes (24/26/28/30Fr). A continuous irrigation system was connected to the nephroscope, with the irrigation saline maintained at a height of 60cm above the patient's center point. Lithotripsy was done using various modalities, including ShockPulse-SE™, ultrasonic lithotripter, pneumatic lithotripter, or Ho:YAG laser, either individually or in combination. The stone fragments were then evacuated through the sheath using suction, the vacuum cleaner effect, or forceps. The collecting system was inspected using a rigid nephroscope and/or a 16Fr-flexible cystoscope to ensure the clearance of any residual stones, and fluoroscopy was also utilized to confirm complete stone clearance. Upon completion of the procedure, the urologist selectively placed either a ureteric stent or a temporary ureteric catheter under fluoroscopic guidance, based on clinical assessment. When the urologist deems a nephrostomy tube necessary, a 16Fr Foley catheter is utilized for mini-PCNL procedures, while an 18Fr Foley catheter is employed for standard PCNL procedures. If the urologist deems it unnecessary, neither a ureteric stent nor a nephrostomy tube is inserted. Additionally, a Foley urethral catheter is placed at the conclusion of the procedure.

On the first postoperative day, a plain radiographic film of the kidney, ureter, and bladder (KUBXR) was obtained to confirm proper positioning of the stent (if any) and evaluate the clearance of radio-opaque calculi. For patients with radiolucent stones, non-contrast computed tomography (NCCT) was performed. If there were no complications and the urine was clear, the urethral catheter, ureteric catheter, and nephrostomy tube were removed, and the patient was discharged. The ureteric stent (if any) was subsequently removed under local anaesthesia at 2 - 6 weeks after the procedure.

Complications were classified using the Clavien-Dindo system, a widely accepted method for reporting surgical complications [20].

The study defined stone-free status as the absence of visible residual stones on KUBXR or NCCT. Treatment success was defined as the absence of clinically significant residual stone fragments (measuring less than 4 mm in maximum diameter).

Statistical analysis was conducted using SPSS version 23. Categorical variables were evaluated through Chi-square test and Fisher's exact test. Continuous variables were assessed using independent samples t-test and Mann-Whitney U test. A statistical significance level of $p < 0.05$ was employed for the analyses.

3. Results

A total of 124 obese patients (BMI > 30 kg/m^2) who underwent percutaneous nephrolithotomy (PCNL) were included in this study: 79 in the supine position and 45 in the prone position.

The sex, age, body mass index (BMI), and American Society of Anesthesiologists physical status classification system (ASA) were comparable between the supine and prone groups with no statistically significant differences observed. The demographic characteristics of the patients are presented in **Table 1**.

The mean stone surface area was 5.68 cm^2 (range: 2.59 - 6.77 cm^2) for the supine group and 11.04 cm^2 (range: 4.85 - 13.98 cm^2) for the prone group. Patients in the prone group had significantly larger total stone burden as shown in **Table 2**.

Table 1. Patient demographic characteristics.

		PCNL position		p-value
		Supine	Prone	
Number of patients		79	45	-
Sex	Male	34 (43%)	20 (44.4%)	0.879
	Female	45 (57%)	25 (55.6%)	
Mean Age (SD)		46 (11.1)	47 (12.7)	0.649
Median Age (Range)		45 (38 - 57)	46 (42 - 54)	0.599
Mean BMI (SD)		33.73 (3.49)	33.96 (3.27)	0.72
Median BMI (Range)		32.89 (30.99 - 35.5)	33.03 (31.62 - 35.11)	0.421
ASA (American Society of Anesthesiologists Physical Status Classification System)	1	4 (5.1%)	4 (8.9%)	0.706
	2	64 (81%)	35 (77.8%)	
	3	11 (13.9%)	6 (13.3%)	

Table 2. Stone Characteristics.

		PCNL position		p-value
		Supine	Prone	
Operative Side	Left	45 (57%)	21 (46.7%)	0.269
	Right	34 (43%)	24 (53.3%)	
Mean stone surface area (cm^2) (SD)		5.68 (6.2)	11.04 (8.25)	<0.001
Median stone surface area (cm^2) (Range)		3.85 (2.59 - 6.77)	9.98 (4.85 - 13.98)	<0.001
Mean Hounsfield Unit (SD)		1186.32 (263.28)	1139.04 (236.27)	0.321
Median Hounsfield Unit (Range)		1200 (1050 - 1350)	1106 (1015 - 1300)	0.149
Guy Stone Score	1	26 (32.9%)	1 (2.2%)	<0.001
	2	29 (36.7%)	12 (26.7)	
	3	15 (19.0%)	13 (28.9)	
	4	9 (11.4%)	19 (42.2%)	

There was a tendency for higher-complexity stones in the prone group according to the Guy stone score.

The Hounsfield Unit (HU) obtained from the non-contrast CT, a surrogate for stone hardness, was comparable between the two groups. The mean Hounsfield Unit (HU) for the supine cohort was 1186.32 ± 263.28 HU (median 1200; range 1050 - 1350), whereas the prone cohort averaged 1139.04 ± 236.27 HU (median 1106; range 1015 - 1300). Neither the mean HU (p = 0.321) nor the median HU (p = 0.149) was statistically different between the two groups.

The perioperative data are presented in Table 3.

The mean operative time was significantly shorter in the supine group than in the prone group (96.9 ± 46.7 minutes vs. 159.6 ± 66.7 minutes; p < 0.001). Subanalysis by Guy Stone Score suggests that the discrepancy in operative time between supine and prone was particularly marked in Guy 2 and Guy 3 cases and less so for Guy 4 (though still numerically higher in prone). The operative time stratified by Guy stone score is shown in Table 4.

Table 3. PCNL perioperative data.

		PCNL position		p-value
		Supine	Prone	
Mean operative time (minutes) (SD)		96.9 (46.7)	159.6 (66.7)	<0.001
Median operative time (minutes) (Range)		85 (65 - 115)	150 (100 - 180)	<0.001
No. of access tract	1	62 (78.5%)	33 (73.3%)	
	2	15 (19%)	10 (22.2%)	0.751
	3	2 (2.5%)	2 (4.4%)	
Tract size (Fr)	14	1 (1.3%)	0 (0%)	
	16	3 (3.8%)	2 (4.4%)	
	24	25 (31.6%)	8 (17.8%)	
	26	40 (50.6%)	25 (55.6%)	0.489
	28	8 (10.1%)	8 (17.8%)	
	30	2 (2.5%)	2 (4.4%)	
Exit strategy	Totally tubeless	2 (2.5%)	0 (0%)	
	Nephrostomy	17 (21.5%)	8 (17.8%)	
	Ureteral catheter	3 (3.8%)	4 (8.9%)	0.28
	DJ stent	14 (17.7%)	7 (15.6%)	
	Nephrostomy + Ureteral catheter	28 (35.4%)	11 (24.4%)	
	Nephrostomy + DJ stent	15 (19%)	15 (33.3%)	
Transfusion (%)		2 (2.6%)	4 (8.9%)	0.113
Transfusion (For patients with Guy Stone Score I, II, III)		1 (1.4%)	1 (3.8%)	0.461
Mean post-operative length of stay (days) (SD)		2.3 (1.6)	2.6 (1.9)	0.378
Median post-operative length of stay (days) (Range)		2 (1-3)	2 (1-3)	0.267

Table 4. Operative time stratified by guy stone score.

Guy Stone Score		PCNL position		p-value
		Supine	Prone	
1	Mean operative time (minutes) (SD)	83.1 (31.6)	75 (-)	0.804
	Median operative time (minutes) (Range)	75 (60 - 108)	75 (75 - 75)	0.963
2	Mean operative time (minutes) (SD)	95.4 (43.1)	134.9 (55.9)	0.019
	Median operative time (minutes) (Range)	85 (65 - 109)	144 (80.5 - 178.5)	0.029
3	Mean operative time (minutes) (SD)	83.7 (30.5)	135.8 (51)	0.003
	Median operative time (minutes) (Range)	75 (65 - 104)	135 (100 - 170)	0.002
4	Mean operative time (minutes) (SD)	163.9 (63.2)	195.9 (68)	0.245
	Median operative time (minutes) (Range)	155 (121 - 190)	175 (140 - 245)	0.223

Most patients in both groups required a single percutaneous access tract (78.5% in supine vs. 73.3% in prone, p = 0.751). There was no statistically significant difference in the distribution of tract diameters used between supine and prone approaches (p = 0.489).

On postoperative imaging, 67.1% of supine and 68.9% of prone patients were stone-free (p = 0.837). When combining stone-free status plus clinically insignificant residual fragments (< 4 mm), the overall treatment success rate was 81% in the supine group vs. 73.3% in the prone group (p = 0.319). This difference was not statistically significant. The stone free rate and treatment success rate are presented in **Table 5**.

Table 5. Stone free rate and treatment success rate.

		PCNL position		p-value
		Supine	Prone	
Overall Stone Free Rate		53 (67.1%)	31 (68.9%)	0.837
Overall Treatment Success Rate		64 (81%)	33 (73.3%)	0.319
Stone Free Rate Stratified by Guy Stone Score	1	22 (84.6%)	1 (100%)	1.000
	2	18 (62.1%)	9 (75%)	0.494
	3	10 (66.7%)	9 (69.2%)	1.000
	4	3 (33.3%)	12 (63.2%)	0.228
Treatment Success Rate Stratified by Guy Stone Score	1	26 (100%)	1 (100%)	-
	2	22 (75.9%)	10 (83.3%)	0.702
	3	12 (80%)	10 (76.9%)	1.000
	4	4 (44.4%)	12 (63.2%)	0.432

2 patients (2.6%) in the supine group and 4 patients (8.9%) in the prone group required transfusion, however, the difference was not statistically significant (p =

0.113). Excluding Guy stone score 4 patients, only 1 patient in the supine group (1.4%) and 1 patient in the prone group (3.8%) required transfusion ($p = 0.461$).

As shown in **Table 6**, a total of 70 patients (88.6%) in the supine group and 34 patients (75.6%) in the prone group had no complications. There was no statistical difference in surgical complications among both groups ($p = 0.134$). Among higher Guy scores (3 and 4), a non-significant trend toward higher complication rates was noted, irrespective of position.

Table 6. PCNL related complications.

		PCNL position		p-value
		Supine	Prone	
Clavien-Dindo classification	No complication	70 (88.6%)	34 (75.6%)	0.134
	1	2 (2.5%)	0 (0%)	
	2	4 (5.1%)	8 (17.8%)	
	3a	1 (1.3%)	1 (2.2%)	
	3b	1 (1.3%)	0 (0%)	
	4a	1 (1.3%)	2 (4.4%)	

The mean hospital stay was 2.3 ± 1.6 days in the supine group and 2.6 ± 1.9 days in the prone group ($p = 0.378$), with median length of stay of 2 days in both groups ($p = 0.267$).

4. Discussion

Our study evaluated two positioning techniques for percutaneous nephrolithotomy (PCNL) in obese patients and demonstrated that both prone and supine approaches yield comparable stone-free and treatment success rates. Although the prone group harboured significantly larger stones ($p < 0.01$), the final stone clearance outcomes were still statistically similar between the two positions. The operative time was substantially shorter in the supine group ($p < 0.001$), supporting its efficiency advantage in obese patients.

A major strength of our study is the strict inclusion of patients who underwent unilateral PCNL while deliberately excluding cases with bilateral procedures or additional concomitant interventions. This strategy minimizes cohort heterogeneity and allows peri-operative outcomes to be attributed more confidently to the choice of patient positioning rather than to confounding differences in procedural complexity.

Moreover, our cohort is substantially larger than that of the only prior retrospective series—124 obese patients versus 42 in the study by Mazzucchi *et al.*—thereby providing greater statistical power to our findings [18].

Previous reports have suggested that the prone position allows for more flexible access to various calyces but can present ergonomic challenges, especially in patients with a higher BMI [14] [18]. The supine position has gained traction due to perceived benefits, including simpler patient positioning, easier airway management, and potential for simultaneous retrograde access (ECIRS) [16] [17].

Our findings corroborate the results of a previous study focused specifically on obese populations undergoing percutaneous nephrolithotomy in the prone or supine position [18]. Comparable complication rates and stone-free outcomes were observed between the two positioning techniques. Similarly, Mazzucchi *et al.* noted high success rates for both approaches in obese patients, though they also identified logistical advantages with the supine position [18]. Notably, our study further reinforces these observations by demonstrating a significantly shorter operative time in the supine group, despite the prone group having a larger average stone burden.

In this study, the difference in operative time was statistically significant, favouring supine PCNL. The prolonged operative time in the prone group can be partly explained by: 1) The need for repositioning and re-draping from lithotomy to prone. 2) Larger and more complex stones in the prone group.

Nonetheless, even with a higher stone burden, the prone group's overall treatment success was comparable, which underscores the technical feasibility of prone PCNL in complex stone disease. In the most complex cases (Guy stone score 4), there was a trend toward higher stone-free and success rates in the prone group, though this was not statistically significant ($p > 0.05$). This may reflect the ease of targeting multiple calyces in the prone position.

The present findings showed no statistically significant difference in surgical complications between supine and prone PCNL in obese patients, in line with multiple meta-analyses showing that neither position has a clear-cut advantage in preventing major complications [15] [16]. However, ensuring appropriate positioning, careful selection of access tract, and optimized perioperative care remain crucial, especially in obese patients who have altered cardiopulmonary physiology and higher baseline surgical risk.

For less complex stones (Guy stone score 1 - 3), supine PCNL's reduced operative time and comparable success rates may make it particularly advantageous in obese patients, who frequently have more challenging anesthetic considerations.

In high-complexity stone scenarios (Guy stone score 4) or whenever extensive multi-tract access is anticipated, some surgeons may prefer the traditional prone approach, especially if they have substantial experience with it.

This study adds to the growing body of evidence that supine PCNL in obese patients is safe, effective, and potentially offers the benefit of reduced operative time. Urologists may consider the supine approach, particularly for cases in which shorter operative time and more efficient airway control are priorities. Future research should aim for prospective, multicentre, randomized comparisons controlling for stone burden to definitively elucidate whether supine PCNL confers superior efficiency while maintaining at least equivalent success and safety outcomes in this high-risk population.

Our retrospective design may limit the generalizability of results, as selection bias and differences in surgeon preference cannot be fully eliminated. Additionally, patients in the prone group presented with significantly larger and more complex stones, which may inherently lengthen operative time. Although the Guy stone score classification provided a structured approach, prospective multi-institutional studies or randomized trials are warranted to confirm these findings in obese patients with varying stone complexities. Additional variables—such as surgeon experience, and operative technique (e.g., mini-PCNL vs. standard PCNL)—should also be explored in future research.

5. Conclusions

In this study involving the largest Asian cohort of 124 obese patients undergoing percutaneous nephrolithotomy, supine and prone approaches achieved statistically indistinguishable stone-free rates, overall treatment success, transfusion requirements, complication profiles, and hospital stay. The only decisive advantage for the supine technique was efficiency: mean operative time was reduced by nearly one hour, an effect most pronounced in Guy Stone Score 2 and 3 cases. Conversely, the prone position remained technically feasible for highly complex (Guy stone score 4) stones, showing a non-significant trend toward greater clearance that may reflect its ease of multicalyceal access.

These data suggest a practical algorithm for obese patients: consider adopting the supine position for unilateral PCNL when stone complexity is low to moderate, and reserve the prone approach for extensive or staghorn calculi when multiple tracts are anticipated and operative time is a secondary concern.

Ethics Approval

The study was duly registered with the National Medical Research Register (NMRR) and received ethical clearance from the Medical Research Ethics Committee (MREC).

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Abbreviations and Acronyms

ASA	American Society of Anesthesiologists physical status classification
BMI	Body Mass Index
cm^2	Square Centimetres
CT	Computed Tomography
DJ Stent	Double J Stent
ECIRS	Endoscopic Combined Intrarenal Surgery
ESWL	Extracorporeal Shockwave Lithotripsy
FBC	Full blood count
Fr	French Gauge
Ho:YAG	Holmium:Yttrium, Aluminium, Garnet
HU	Hounsfield Unit
kg	Kilogram
kg/m^2	Kilogram per square meter
KUBXR	X-ray of the Kidney, Ureter and Bladder
m^2	Square metres
mm	Millimetre
min	Minutes
NCCT	Non-Contrast Computed Tomography
PCNL	Percutaneous Nephrolithotomy
RIRS	Retrograde Intrarenal Surgery
RPG	Retrograde Pyelogram
SFR	Stone free rate
SD	Standard Deviation
USG	Ultrasound