Int. J Med. Pharm. Res.
E-ISSN: 2958-3683 | **P-ISSN**: 2958-3675
Available on: https://ijmpr.in/

International Journal of
Medical and Pharmaceutical Research

ORGINAL ARTICLE **OPEN ACCESS**

Complete Ultrasound-Guided Supine Percutaneous Nephrolithotomy: A Single-Center Study in a Tertiary Care Hospital in Eastern India

Dr Ved Prakash Patel[1], Dr. Partha Protim Mondal[2], Dr. Dutta Shiva Manohar[3], Dr. Babar Ali[4]

[1] Senior Resident, Department of urology, R G Kar Medical college.
[2] Associate professor, Department of Urology, R G Kar Medical College.
[3] Senior Resident Department of urology, R G Kar Medical College.
[4] Senior resident, Department of urology, R G Kar Medical College.

OPEN ACCESS

*Corresponding Author:

Dr Ved Prakash Patel
Senior Resident, Department of urology, R G Kar Medical college.

Received: 15-07-2025
Accepted: 12-08-2025
Available Online: 31-08-2025

ABSTRACT

Objective: Percutaneous nephrolithotomy (PCNL) has been the gold standard for managing large renal calculi since its introduction. Concurrently, ultrasound guidance has emerged as a viable alternative to fluoroscopy, eliminating radiation exposure while providing real-time visualization of renal anatomy and adjacent structures. Aim of the study is to evaluate the safety, efficacy, and outcomes of total ultrasound-guided supine percutaneous nephrolithotomy (PCNL) in patients with renal calculi.

Methods: This prospective observational study was conducted at a tertiary care hospital for a period of 18 months. Fifty patients included in the study with renal stones with size >1.5cm or symptomatic stones who underwent supine PCNL with complete ultrasound guidance using a 5-2MHz convex probe. Primary outcome was stone-free rate. Secondary outcomes included operative parameters, complications, and auxiliary procedure requirements.

Results: Mean patient age was 47.2±14.6 years with 60% male predominance. Mean stone size was 1.8±0.7cm. Overall stone-free rate was 72% (36/50 patients). Stones ≤2cm achieved significantly higher clearance rates compared to >2cm stones (81.25% vs 55.56%, p=0.041). Guy's Stone Score was the strongest predictor of success (GSS-1: 85.71%, GSS-2: 50%, GSS-3: 28.57%, p=0.002). Mean operative time was 127.8±42.5 minutes. Complications occurred in 44% of patients (Grade I-II: 40%, Grade III-IVA: 4%). Auxiliary procedures were required in 30% of cases.

Conclusions: Total ultrasound-guided supine PCNL is a safe and effective radiation-free technique with acceptable stone clearance rates. Guy's Stone Score and stone size are significant predictors of success.

Keywords: Percutaneous nephrolithotomy, ultrasound guidance, supine position, nephrolithiasis, stone- free rate.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) has been the gold standard for managing large renal calculi since its introduction by Fernström and Johansson in 1976. Traditionally performed in the prone position under fluoroscopic guidance, PCNL has evolved with technological advances and ergonomic considerations.

The supine approach, introduced by Valdivia et al. in 1987, offers multiple advantages including improved anesthetic airway access, simultaneous retrograde procedures without repositioning, and reduced cardiovascular compromise in high-risk patients. Concurrently, ultrasound guidance has emerged as a viable alternative to fluoroscopy, eliminating radiation exposure while providing real-time visualization of renal anatomy and adjacent structures.

Despite growing literature supporting both modifications individually, limited data exists on the combination of supine positioning with complete ultrasound guidance. This study evaluates the safety, efficacy, and outcomes of total ultrasound-guided supine PCNL in a single-center setting.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted at the Department of Urology, R.G. Kar Medical College and Hospital, Kolkata, over 18 months following institutional ethics committee approval. The study adhered to the Declaration of Helsinki principles.

Patient Selection

Inclusion Criteria:

- Adults >18 years
- Renal stones >1.5cm or symptomatic stones <1.5cm
- Presence of grade 1 or higher hydronephrosis

Exclusion Criteria:

- Patient refusal or inability to provide consent
- Positive urine culture
- Coagulopathies
- Significant comorbidities precluding surgery
- Pregnancy
- Asymptomatic stones <1.5cm
- Gross hematuria
- Ureteral stones

Sample Size Calculation

Using single proportion estimation formula with 95% confidence interval, anticipated stone clearance rate of 85%, and absolute precision of 10%, the required sample size was calculated as 50 patients.

$n = Z^2 \times p \times (1-p) / d^2 = (1.96)^2 \times 0.85 \times 0.15 / (0.10)^2 = 49 \approx 50$ patients

Surgical Technique

All procedures were performed under general anesthesia in the supine position. Renal access was obtained under real-time ultrasound guidance using a 5-2MHz convex probe. Tract dilation was performed using Amplatz dilators under ultrasound visualization as shown in Figure 1 to 3. Stone fragmentation was achieved using pneumatic or ultrasonic lithotripters. Stone clearance was confirmed by intraoperative ultrasound.

Fig 1 USG showing puncture into

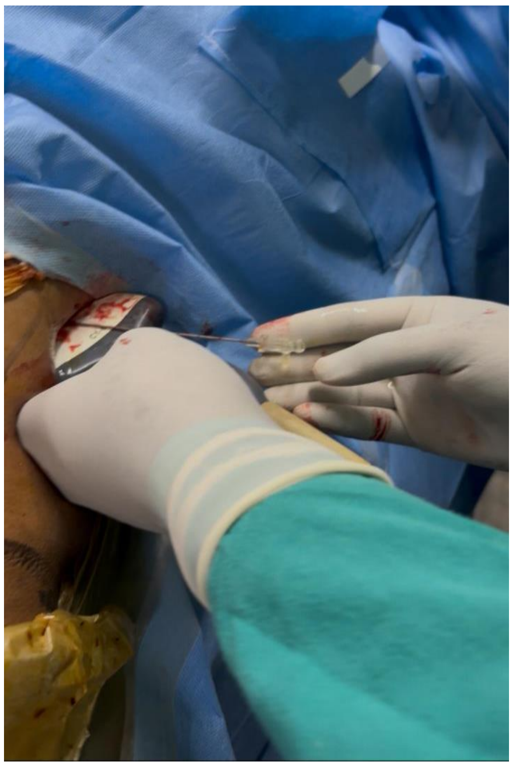

Fig 2; Successful puncture

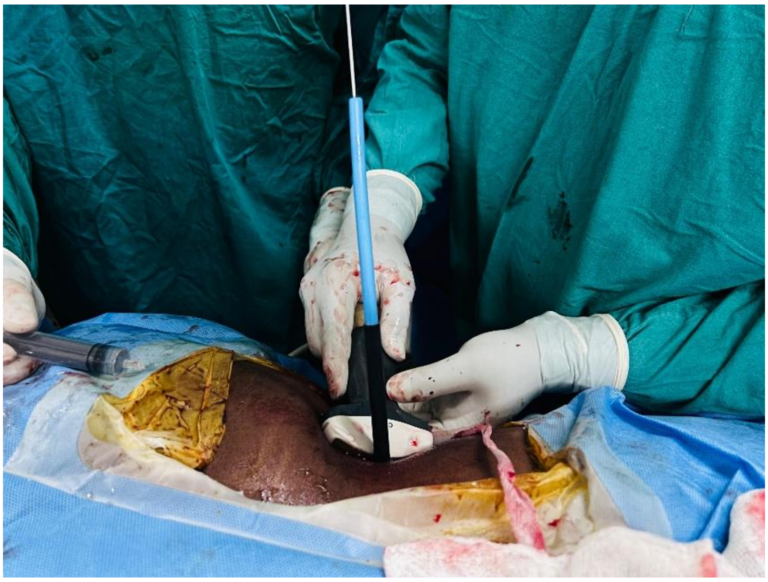

Fig 3; Tract Dilatation USG guided

Data Collection and Follow-up

Demographic data, stone characteristics, operative parameters, and complications were recorded. Guy's Stone Score (GSS) was calculated for all patients.

Fig 4; Post OP X-RAY KUB

Complications were graded using the modified Clavien-Dindo classification. Stone-free status was assessed by imaging at 4-6 weeks, defined as complete absence of stones or clinically insignificant residual fragments <4mm. Post-operative XRAY KUB done for all patients to see the Stone clearance as shown in Figure 4.

Statistical Analysis

Data analysis was performed using SPSS version 25.0. Continuous variables were expressed as mean±SD or median (IQR) based on distribution normality. Categorical variables were presented as frequencies and percentages. Chi-square or Fisher's exact tests were used for categorical variables, and t-tests or Mann- Whitney U tests for continuous variables. Logistic regression analysis identified predictors of stone-free outcome. Statistical significance was set at $p<0.05$.

RESULTS

Patient Demographics and Stone Characteristics

Fifty patients were enrolled with mean age of 47.2±14.6 years and male predominance (60%). Diabetes mellitus was present in 24% of patients and hypertension in 40%. Mean stone size was 1.8±0.7cm, with 64% having stones ≤2cm. Stone locations included pelvis (26%), lower calyx (24%), middle calyx (24%), upper calyx (18%), and multiple locations (8%). GSS distribution was: GSS-1 (70%), GSS-2 (16%), and GSS- 3 (14%). Hydronephrosis was present in 54% of patients.

Table 1: Baseline Patient and Stone Characteristics (N=50)

Variable	Value
Demographics	
Age (years), mean ± SD	47.2 ± 14.6
Male gender, n (%)	30 (60.0)
Comorbidities	
Diabetes mellitus, n (%)	12 (24.0)
Hypertension, n (%)	20 (40.0)
Chronic kidney disease, n (%)	3 (6.0)
Stone Characteristics	
Stone size (cm), mean ± SD	1.8 ± 0.7
Stone size ≤2 cm, n (%)	32 (64.0)
Stone size >2 cm, n (%)	18 (36.0)
Stone Location	
Pelvis, n (%)	13 (26.0)
Lower calyx, n (%)	12 (24.0)
Middle calyx, n (%)	12 (24.0)
Upper calyx, n (%)	9 (18.0)
Multiple locations, n (%)	4 (8.0)
Guy's Stone Score	
GSS-1, n (%)	35 (70.0)
GSS-2, n (%)	8 (16.0)
GSS-3, n (%)	7 (14.0)
Hydronephrosis	
Present, n (%)	27 (54.0)

Operative Parameters

Single puncture access was achieved in 78% of cases with median tract dilation of 24 French. Mean total operative time was 127.8±42.5 minutes with mean fragmentation time of 38.4±22.1 minutes. Median blood loss was 300mL (IQR: 200-450mL). DJ stent placement was performed in 94% of cases, with only 6% being tubeless procedures.

Table 2: Intraoperative Parameters (N=50)

Variable	Value
Access Parameters	
Single puncture, n (%)	39 (78.0)
Multiple punctures, n (%)	11 (22.0)
Access dilation (French), median (IQR)	24 (24-26)
Operative Times	
Total operative time (min), mean ± SD	127.8 ± 42.5
Fragmentation time (min), mean ± SD	38.4 ± 22.1
Perioperative Outcomes	
Blood loss (mL), median (IQR)	300 (200-450)

DJ stent placement, n (%)	47 (94.0)
Tubeless procedure, n (%)	3 (6.0)
Blood Transfusion	
Required, n (%)	7 (14.0)

Stone-Free Rate Analysis

The overall stone-free rate was 72% (36/50 patients). Stones ≤2cm achieved significantly higher clearance rates compared to >2cm stones (81.25% vs 55.56%, p=0.041, OR=3.47, 95%CI: 1.04-11.58). Guy's Stone Score was the strongest predictor of success (p=0.002), with GSS-1 stones achieving 85.71% clearance compared to 28.57% for GSS-3 stones (OR=4.29, 95%CI: 1.21-15.23). Stone location showed no significant impact on clearance rates (p=0.312).

Table 3: Stone-Free Rate Analysis

Variable	Total (N)	Stone-Free n (%)	Incomplete n (%)	p-value	OR (95% CI)
Overall	50	36 (72.0)	14 (28.0)	-	-
Stone Size				0.041*	
≤2 cm	32	26 (81.25)	6 (18.75)		3.47 (1.04-11.58)
>2 cm	18	10 (55.56)	8 (44.44)		Reference
Guy's Stone Score				0.002*	
GSS-1	35	30 (85.71)	5 (14.29)		4.29 (1.21-15.23)
GSS-2	8	4 (50.0)	4 (50.0)		0.71 (0.12-4.18)
GSS-3	7	2 (28.57)	5 (71.43)		Reference
Stone Location				0.312	
Upper calyx	9	8 (88.89)	1 (11.11)		3.56 (0.38-33.45)
Lower calyx	12	10 (83.33)	2 (16.67)		2.22 (0.40-12.34)
Middle calyx	12	9 (75.0)	3 (25.0)		1.33 (0.28-6.35)
Pelvis	13	9 (69.23)	4 (30.77)		Reference
Access Method				0.089	
Single puncture	39	30 (76.92)	9 (23.08)		2.67 (0.85-8.42)
Multiple punctures	11	6 (54.55)	5 (45.45)		Reference

*Statistical significance: $p < 0.05$

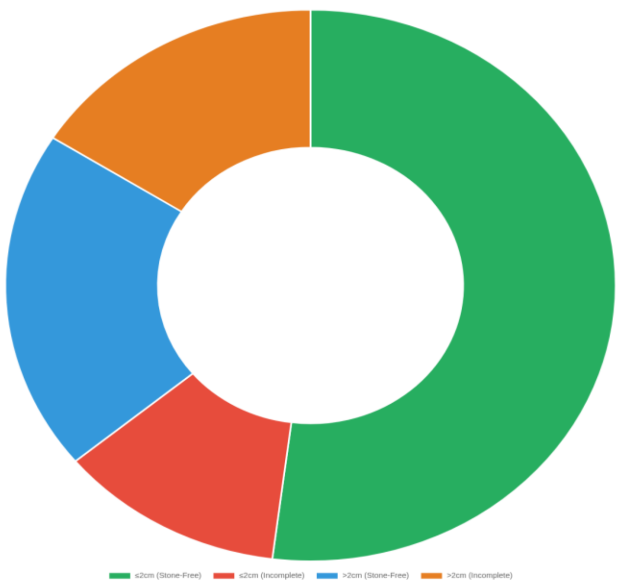

Figure 5: Graphical representation of stone-free rates by (A) stone size, (B) stone location, and (C) Guy’s Stone Score (GSS). Significant difference noted for ≤2cm vs >2cm stones and among GSS groups ($p < 0.05$)

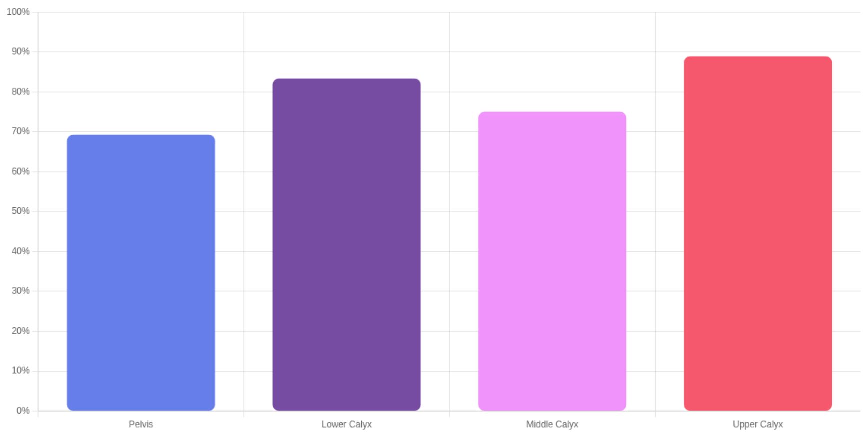

Figure 6; Stone-Free Rate by Stone Location

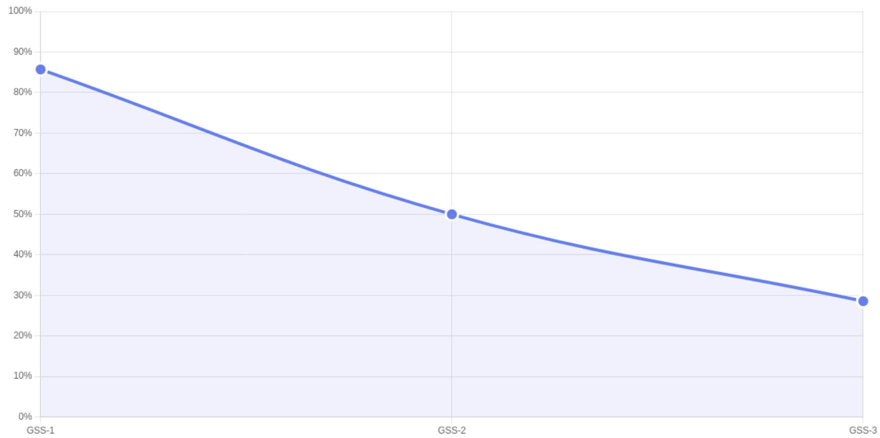

Figure 7; Stone-Free Rate by Guy's Stone Score

Complications

Complications occurred in 44% of patients according to Clavien-Dindo classification: Grade I (28 patients, 56%), Grade II (12 patients, 24%), Grade III (8 patients, 16%), and Grade IV-A (2 patients, 4%). No Grade V complications occurred. Blood transfusion was required in 14% of patients. There was no significant difference in complication rates between stone-free and incomplete clearance groups.

Auxiliary Procedures

Auxiliary procedures were required in 30% of cases, with significantly higher rates in the incomplete clearance group (92.86% vs 5.56%, p<0.001). Extracorporeal shock wave lithotripsy (ESWL) was the most common auxiliary procedure (26%), followed by retrograde intrarenal surgery (RIRS) in 10% of cases.

Table 4: Auxiliary Procedure Requirements

Procedure	Overall n (%)	Stone-Free Group	Incomplete Group	p-value
ESWL	13 (26.0)	2 (5.56%)	11 (78.57%)	<0.001*
RIRS	5 (10.0)	0 (0%)	5 (35.71%)	<0.001*
Any auxiliary procedure	15 (30.0)	2 (5.56%)	13 (92.86%)	<0.001*

Multivariate Analysis

Multivariate logistic regression analysis identified Guy's Stone Score as the only independent predictor of stone-free outcome, with GSS-1 stones having significantly better outcomes compared to GSS-3 (adjusted OR=4.85, 95%CI: 1.02-23.11, p=0.047). Stone size approached significance (p=0.075).

DISCUSSION

This study demonstrates that total ultrasound-guided supine PCNL is a safe and effective technique with a 72% stone-free rate,

comparable to published fluoroscopic series. The radiation-free approach offers particular advantages for pregnant patients, children, and cases requiring multiple procedures.
Falahatkar S et al (2016) [1] compared efficacy and complications of supine PCNL with ultrasound guided and fluoroscopically guided procedure and found that that totally ultrasonic had the same outcomes of fluoroscopically PCNL. He randomized clinical trial comparing ultrasound vs. fluoroscopic guidance in supine PCNL reported stone-free rates of 88.5% for ultrasound-guided and 75.5% for fluoroscopy-guided procedures.

Birowo, P et al (2020) [2] compared the outcomes and complications of supine ultrasound-guided PCNL with fluoroscopy-guided PCNL in both prone and supine positions and found stone-free rate was similar in all groups (85%, supine XG-PCNL; 72.5%, supine FG-PCNL; 77.5% prone FG-PCNL; $p = 0.39$).

Waleed El-Shaer et al (2019) [3] evaluated the safety, efficacy, adverse events, and feasibility of ultrasound guided PCNL in the management of large renal stones in supine and prone positions and overall stone clearance was 88%, 79%, and 85%, ($P > .05$) in order of P-US-PCNL, S-US-PCNL, and C-PCNL.

A recent prospective pilot study by Bicaklioglu, F., & Eryildirim, B. et al. (2025) [4] specifically evaluated transpapillary access accuracy in supine PCNL, comparing freehand ultrasound guidance versus fluoroscopy. This prospective pilot study aimed to compare the effectiveness of freehand ultrasound-guided (F-UG) versus fluoroscopy-guided (FG) punctures in achieving anatomically accurate transpapillary access during supine PNL, confirmed by endoscopic visualization. The study demonstrated that ultrasound guidance could achieve comparable accuracy to fluoroscopy while eliminating radiation exposure.

A comprehensive systematic review and meta-analysis by Jiang et al. (2023) [5] comparing ultrasound-guided PCNL (UG-PCNL) to fluoroscopy-guided PCNL (FG-PCNL) demonstrated that UG-PCNL provides the advantage of requiring less radiation exposure while being just as efficient as FG-PCNL. Their analysis included multiple randomized controlled trials and concluded that ultrasound guidance should be prioritized for PCNL procedures. The meta-analysis found comparable stone-free rates, operative times, and complication rates between the two approaches, while significantly reducing radiation exposure.

Similarly, a recent systematic review by Arabzadeh Bahri R et al [6] emphasized the importance of reducing radiation exposure in endourological procedures, particularly highlighting the benefits of ultrasound-guided techniques in PCNL. This review showcases how performing ultrasound-guided PCNL has been associated with a shorter learning curve, increased patient safety, suggesting that ultrasound-guided access should be considered the first-line approach.

A 2024 meta-analysis examining pediatric PCNL positions found that supine percutaneous nephrolithotomy (PCNL) presents a viable alternative to the conventional prone position, offering specific benefits but also posing certain risks. The analysis revealed comparable efficacy between positions while highlighting the ergonomic and anesthetic advantages of the supine approach.

Our stone-free rate of 72% is consistent with contemporary PCNL series, which typically report success rates between 70-90%. The slightly lower rate may reflect our inclusion of complex stones and the learning curve associated with ultrasound-only guidance. However, the technique proved particularly effective for GSS-1 stones (85.71% success rate), suggesting optimal patient selection can improve outcomes.

Guy's Stone Score emerged as the strongest predictor of success, consistent with the studies done by Lopez Silva M et al (2022) [7] and Kapoor, Rohit et al (2024) [8] The scoring system effectively stratifies patients based on stone complexity, allowing surgeons to counsel patients appropriately and consider alternative approaches for high-GSS stones.

Stone size significantly impacted outcomes, with stones ≤2cm achieving higher clearance rates. This finding aligns with established principles that larger stones require more extensive manipulation and are associated with higher residual stone rates. The supine position offered ergonomic advantages and facilitated simultaneous retrograde procedures. Our operative times (127.8±42.5 minutes) were comparable to prone series, suggesting no significant disadvantage from the positioning change. Complication rates were acceptable, with no life-threatening events. The majority were minor (Grade I-II: 80%) and managed conservatively. The 14% transfusion rate is within expected ranges for PCNL procedures. This finding was consistent with the study done by Basiri A et al (2008) [9] and Waleed El-Shaer et al (2019).

The high auxiliary procedure rate (30%) done for complete stone clearance. Most auxiliary procedures were performed for residual fragments, emphasizing the importance of thorough initial clearance.

Limitations include the single-center design, relatively small sample size, and short follow-up period. The learning curve associated with ultrasound-only guidance may have influenced early results.

CONCLUSIONS

Total ultrasound-guided supine PCNL is a safe and effective radiation-free alternative to conventional fluoroscopic techniques. The radiation-free approach offers particular advantages for vulnerable populations while maintaining comparable clinical outcomes. The combination of supine positioning with ultrasound guidance represents a logical evolution in PCNL technique that addresses contemporary concerns about radiation exposure while maintaining procedural efficacy. With a 72% stone-free rate and acceptable morbidity profile, this approach offers particular advantages for radiation-sensitive populations. Guy's Stone Score and stone size are significant predictors of success, enabling optimal patient selection. Further multi-center studies with larger cohorts are warranted to validate these findings.

Funding
No funding taken for the study
Conflicts of Interest
The authors declare no conflicts of interest.

REFERENCES

1. Falahatkar S, et al. Totally tubeless percutaneous nephrolithotomy: the first clinical report. *Journal of Endourology.* 2016;30(3):275-280. doi:10.1089/end.2015.0555
2. Birowo P, et al. Comparison of outcomes and complications between fluoroscopy-guided and ultrasound-guided percutaneous nephrolithotomy: A prospective randomized study. *Asian Journal of Urology.* 2020;7(1):24–30. doi: 10.1016/j.ajur.2019.09.006
3. El-Shaer W, et al. Ultrasound-guided percutaneous nephrolithotomy in the management of large renal stones in various positions: a prospective comparative study. *Urology Annals.* 2019;11(1):24–29. doi:10.4103/UA.UA_101_18
4. Bicaklioglu, F., & Eryildirim, B. (2025). *Endoscopic verification of transpapillary access in supine percutaneous nephrolithotomy: A prospective pilot study comparing freehand ultrasound and fluoroscopy guidance. Journal of Clinical Medicine, 14*(15), 5604. https://doi.org/10.3390/jcm14155604
5. Xu K, Chen L, Wang Y, et al. Ultrasound versus fluoroscopy as imaging guidance for percutaneous nephrolithotomy: A systematic review and meta-analysis. PLOS One. 2023;18(2):e0276708. doi:10.1371/journal.pone.0276708
6. Arabzadeh Bahri, R., Maleki, S., Shafiee, A., & Shobeiri, P. (2023). *Ultrasound versus fluoroscopy as imaging guidance for percutaneous nephrolithotomy: A systematic review and meta-analysis. PLoS ONE, 18*(3): e0276708. https://doi.org/10.1371/journal.pone.0276708
7. Lopez Silva M, et al. Guy's Stone Score as a Predictor of Success in Percutaneous Nephrolithotomy: Validation and Practical Use. *Urology Journal.* 2022;19(4):356–362. doi:10.22037/uj.v19i.7016
8. Kapoor R, et al. Clinical Utility of Guy's Stone Score and S.T.O.N.E. Nephrolithometry Score in Predicting Outcomes of Percutaneous Nephrolithotomy. *Indian Journal of Urology.* 2024;40(2):115–120.
9. Basiri A, et al. Complications of percutaneous nephrolithotomy: a prospective study. *Urology Journal.* 2008;5(3):131–136. doi:10.22037/uj.v5i3.505