Annals of R.S.C.B., ISSN:1583-6258, Vol. 24, Issue 1, 2020, Pages. 1640 - 1648
Received 08 April 2020; Accepted 15 May 2020

Comparative Study Between Ultrasonic and Fluoroscopic Guided PCNL in Blood Loss and Stone-Free Rate.

Ali Mohammed Abdulameer

Al-Muthanna University ,College of Medicine, M.B.Ch.B., F.I.C.M.S.(Uro.)

Abstract:

Objective:
This study aimed to compare the effectiveness of ultrasound-guided and fluoroscopy-guided percutaneous nephrolithotomy (PCNL) in terms of stone-free rates and blood loss, as well as secondary outcomes such as operative time, hospital stay, and complication rates.

Methods:
One hundred patients with renal stones scheduled for PCNL were divided into two groups. Group A (50) underwent ultrasound-guided PCNL, while Group B (50) underwent fluoroscopy-guided PCNL. The same surgeon performed all procedures in the prone position, using 30 Fr Amplatz sheaths for access. Doppler ultrasound was employed in Group A to minimize vascular injury.

Results:
Stone-free rate was 80 percent in Group A (ultrasound) and 90 percent in Group B (fluoroscopy), slightly better for fluoroscopy. Mean blood loss was less in Group A (250± 80 mL) than in Group B (310 90 mL). Moreover, there was no decline in hemoglobin either in the ultrasound-guided (1.2 ±0.4 g/dL) or the fluoroscopy group (1.5 ± 0.5 g/dL). A patient in Group A and two in Group B needed blood transfusions. Secondary results showed a shorter operative time for Group B (70 ±10 minutes) than for Group A (85± 12 minutes). Meanwhile, the hospital stay was similar for each group (2.2± 0.6 days for ultrasound; 2.1 ± 0.5 days for fluoroscopy). Complication rates were similar: 6 cases (12%) of Grade I/II complications per group in Group A and 7 cases (14%) in Group B.

Conclusion:
Ultrasound- and fluoroscopy-based PCNL are viable treatments for renal stones, but they have different strengths. Ultrasound-guided blood loss and hemoglobin loss were minimized, while fluoroscopy guided a slightly higher stone-free rate and shorter operative time. Given similar safety profiles, ultrasound-guided PCNL might be an alternative to fluoroscopy if eliminating radiation and bleeding offsets the benefits.

Keywords: PCNL, Stone, Ultrasound, Fluoroscopy

Introduction

The treatment of patients with high kidney stones by the minimally invasive alternative to open surgery, PCNL, has changed the world. PCNL is especially helpful for over 2 cm, complicated, or staghorn stones and those not responding to less invasive treatments such as extracorporeal shock wave lithotripsy (ESWL) or ureteroscopy (1). However, even for the surgery's virtues, PCNL is technically challenging and a complicated procedure that requires accurate imaging for best results and patient safety. In PCNL, ultrasound and fluoroscopy are the two most commonly used imaging techniques, but they have different strengths and weaknesses (2).

Fluoroscopy, the conventional imaging technique for PCNL, offers a fine-resolution picture of the urinary system and precise indications for entry and dilation of the tract. It helps detect the stone position and renal calyces, which can be used to remove hard or large calculi accurately. However, the use of ionizing radiation poses substantial health risks for both patients who regularly receive it and surgeons who do so often. That radiation risk has generated curiosity for other imaging methods—specifically ultrasound (3,4).

Annals of R.S.C.B., ISSN:1583-6258, Vol. 24, Issue 1, 2020, Pages. 1640 - 1648
Received 08 April 2020; Accepted 15 May 2020

Several advantages of ultrasound-guided PCNL include reduced exposure to radiation, so the procedure is preferred to decrease cumulative radiation doses to patients and healthcare providers. What is more, ultrasound can provide near-real-time Doppler imaging so that we can see blood flow and minimize the risk of vascular damage, which is essential when you are just getting your first kidneys (5). This technique can avoid bleeding complications by pinpointing a vascular bed's anatomy before dilating it. However, ultrasound is not foolproof, especially in patients with a high BMI or a kidney with an intricate anatomy, in which the anatomy can be more complex to discern than in fluoroscopic views (6).

Various comparisons have been made between ultrasound and fluoroscopic guidance for PCNL with different stone clearance and safety results. An inquiry by (7) compared PCNL patient outcomes with ultrasound and fluoroscopic inspection. It determined that ultrasound gave similar rates of stone-free status as fluoroscopy, with less radiation exposure and less total loss of blood. In contrast, (8) observed slightly more excellent stone-free rates under fluoroscopic observation, particularly in the complicated stone burdens or unusual renal anatomy, indicating that fluoroscopy could be helpful in these patients. However, (8) noticed more blood loss due to fluoroscopic inspection, probably because no Doppler was scanning for vessel structures.

The data in these studies indicates that both imaging approaches have positional advantages. Fluoroscopy can be used on a patient with anatomically complex anatomy or with big, complicated stones. Ultrasound might be more appropriate, by contrast, for those who are at high risk of bleeding or require regular imaging (9). It is not yet clear which imaging method is the most helpful, as each technique’s usefulness depends on the experience of the surgeon, the patient, and the stone. Therefore, this article aims to add to the evidence body comparing stone-free rate and blood loss in ultrasound-only and fluoroscopy-only guided PCNL (10,11). This paper aims to evaluate whether or not ultrasound-guided vs fluoroscopy-guided PCNL results are equivalent, that is, stone-free rate and bleeding loss. We will analyze results in a trial of 100 patients, split equally between the two strategies, and make all the surgeries done by the same highly experienced surgeon so operator-related variables can be kept to a minimum. This investigation also attempts to measure secondary outcomes, including operation time, length of hospital stay, and complication rate. They significantly impact the patient’s rehabilitation and healthcare needs and are very relevant to the comparative analysis. Our research may have the potential to change the future of PCNL. It will significantly improve patients' recovery and quality of life and provide insight into the utility and value of our findings for the medical community (12).

By evaluating these outcomes, this study aims to contribute valuable insights that may help optimize PCNL technique selection based on individual patient profiles and clinical requirements. Ultimately, this research could provide a foundation for guidelines that enhance surgical safety and efficacy in renal stone management, offering a promising future for PCNL procedures.

Methods

Study Design

Annals of R.S.C.B., ISSN:1583-6258, Vol. 24, Issue 1, 2020, Pages. 1640 - 1648
Received 08 April 2020; Accepted 15 May 2020

It was a prospective, randomized, controlled trial with 100 renal stone patients. They had PCNL appointments and were randomized into two groups: Group A (n=50), ultrasound-guided PCNL, and Group B (n=50), fluoroscopy-guided PCNL. The study was ethically conducted according to the institutional policy, and informed consent was obtained from everyone.

Patients were selected based on the following criteria:

- **Inclusion Criteria**: Patients with renal stones measuring ≥2 cm in diameter, stone composition as assessed by imaging, no previous history of PCNL, and suitability for prone positioning.
- **Exclusion Criteria**: Patients with uncorrected coagulopathy, pregnancy, contraindications to anesthesia, complex renal anomalies, or BMI over 40 due to limitations in ultrasound visualization.

Procedural Technique

Both PCNL methods were performed under general anesthesia, with the patient positioned prone. The procedures were standardized across groups and performed by the same experienced urologist to ensure consistency and minimize operator bias.

- **Ultrasound-Guided PCNL (Group A)**: Real-time ultrasound imaging was used for renal access and initial puncture. Doppler imaging was employed frequently to avoid major renal vessels during tract creation, and access was achieved through sequential dilation with metal dilators to minimize injury risk. The final tract was established using a 30 Fr Amplatz sheath.
- **Fluoroscopy-Guided PCNL (Group B)**: Fluoroscopy was utilized to identify the target calyx, establish renal access, and confirm tract alignment. One-step dilation was performed, and the 30 Fr Amplatz sheath was similarly applied to access the renal pelvis.

Outcome Measures

The primary outcomes were the stone-free rate and blood loss, defined as follows:

- **Stone-Free Rate**: The absence of residual stones confirmed by post-operative imaging (ultrasound and KUB radiography) on day 1.
- **Blood Loss**: Estimated by intraoperative estimation of blood loss and hemoglobin reduction measured 24 hours post-operation. Blood transfusions administered were recorded for comparison.

Secondary outcomes included:

- **Operative Time**: Measured from the first puncture to the completion of stone extraction.
- **Hospital Stay**: Duration in days from the surgery to discharge.
- **Complications**: Intraoperative and postoperative complications, recorded and classified using the modified Clavien-Dindo grading system.

Results:

The baseline demographic and clinical characteristics are presented in Table 1. The mean age of the participants in Group A (ultrasound-guided) was 45 years, with a standard deviation (SD) of 13 years, while in Group B (fluoroscopy-guided), it was 47 years, with an SD of 12 years. Both groups were nearly evenly distributed by gender, with 25 males and 25 females in Group

Annals of R.S.C.B., ISSN:1583-6258, Vol. 24, Issue 1, 2020, Pages. 1640 - 1648
Received 08 April 2020; Accepted 15 May 2020

A, compared to 27 males and 23 females in Group B. The mean body mass index (BMI) was slightly higher in Group A (29.4 ± 4.2 kg/m²) compared to Group B (28.7 ± 4.5 kg/m²). The average stone size was similar between groups, measuring 2.7 ± 0.6 cm in Group A and 2.8 ± 0.7 cm in Group B. In terms of stone location, Group A had 28 stones located in the calyx and 22 in the renal pelvis, while Group B had 30 in the calyx and 20 in the renal pelvis (Table 1).

Table 1. Baseline Demographics and Characteristics

Parameter	Group A (Ultrasound)	Group B (Fluoroscopy)
Age (years)	45 ± 13	47 ± 12
Gender (M/F)	25/25	27/23
BMI (kg/m²)	29.4 ± 4.2	28.7 ± 4.5
Stone Size (cm)	2.7 ± 0.6	2.8 ± 0.7
Stone Location (Calyx/Renal Pelvis)	28/22	30/20

The primary outcomes focused on the stone-free rate and blood loss, as summarized in Table 2. The stone-free rate was higher in Group B, with 90% of patients achieving a stone-free status after the procedure compared to 80% in Group A. Mean blood loss was significantly lower in Group A (250 ± 80 mL) than in Group B (310 ± 90 mL), suggesting that ultrasound guidance might reduce blood loss during PCNL. Regarding transfusion requirements, only one patient in Group A required a transfusion. In contrast, two patients in Group B required a transfusion (Table 2).

Table 2. Primary Outcomes: Stone-Free Rate and Blood Loss

Outcome	Group A (Ultrasound)	Group B (Fluoroscopy)
Stone-Free Rate (%)	80	90
Mean Blood Loss (mL)	250 ± 80	310 ± 90
Transfusion Requirement	One patient	Two patients

The secondary outcomes, which included operative time, hospital stay, and complications, are detailed in Table 3. The average operative time was longer for Group A (85 ± 12 minutes) than Group B (70 ± 10 minutes), indicating that ultrasound-guided PCNL may take longer. Hospital stay was similar between groups, with an average of 2.2 ± 0.6 days in Group A and 2.1 ± 0.5 days in Group B. Complication rates were also comparable; 6 patients (12%) in Group A experienced minor complications, classified as Grade I or II, compared to 7 patients (14%) in Group B. Most minor complications included transient hematuria and low-grade fever, managed conservatively (Table 3).

Annals of R.S.C.B., ISSN:1583-6258, Vol. 24, Issue 1, 2020, Pages. 1640 - 1648
Received 08 April 2020; Accepted 15 May 2020

Table 3. Secondary Outcomes: Operative Time, Hospital Stay, and Complications

Outcome	Group A (Ultrasound)	Group B (Fluoroscopy)
Operative Time (minutes)	85 ± 12	70 ± 10
Hospital Stay (days)	2.2 ± 0.6	2.1 ± 0.5
Complications (Grade I/II)	6 (12%)	7 (14%)

Discussion

The results of this study highlight the relative advantages and limitations of ultrasound-guided versus fluoroscopy-guided PCNL for managing renal stones, explicitly focusing on stone-free rates, blood loss, and operative efficiency. Each technique has unique strengths that could guide clinical decision-making, depending on patient factors and surgical goals.

Stone-Free Rate

Group B (fluoroscopy-guided) had a higher stone-free rate (90%) than Group A (ultrasound-guided) (80%). The superior stone-free rate observed in fluoroscopy ties in with several previous publications (13,14), which show that fluoroscopic guidance can help illustrate complex stone structures and reach the most restricted calyces. These considerations can be particularly true for large stones or hard-to-reach anatomical locations where ultrasound's tissue-specific constraints might affect access and mobility (15,16). Although helpful in reducing radiation dose and preventing vessel damage, ultrasound guidance can be limited in displaying tiny or calyceal stones with crisp resolution (17). That limitation might account for the slightly lower stone-free rate in Group A. However, even with this discrepancy, ultrasound-guided PCNL had a high clearance rate, and its use as a substitute can be justified, particularly for patients who are more vulnerable to radiation or want to avoid exposure to too much radiation (18).

Blood Loss and Hemoglobin Reduction

Some interesting data was that less blood was lost in the ultrasound-guided group compared with the fluoroscopy-guided group (average loss: 250± 80 mL vs 310± 90 mL). This disparity in blood loss could be because Doppler ultrasound is used in the procedure, which allows you to see vascular architecture in real time, thereby reducing vascular damage. Studies by (19) also demonstrated that ultrasound guidance helps to avoid damaging segmental vessels, which reduces the amount of intraoperative blood loss and transfusions (20,21). The blood loss reduction is clinically meaningful as it could decrease transfusions, as this study demonstrated (1 transfusion in Group A and two transfusions in Group B). Lower transfusion and blood loss will mean reduced post-operative mortality and quicker recovery, according to studies of high-risk patients (22). This observation shows the safety benefits of ultrasound guidance for bleeding patients or those in whom blood loss must be reduced.

Operative Time

The operative time was shorter with fluoroscopy-guided PCNL (70 ±10 minutes) than ultrasound-guided PCNL (85 ±12 minutes), perhaps due to the faster localization and puncture

Annals of R.S.C.B., ISSN:1583-6258, Vol. 24, Issue 1, 2020, Pages. 1640 - 1648
Received 08 April 2020; Accepted 15 May 2020

with fluoroscopic imaging. Fluoroscopy allows you to see the kidney in real-time and locate it in the urinary tract more quickly, possibly reducing the time to surgery. This result aligns with literature data suggesting fluoroscopy often speeds up access (18,21).

However, the tiny time delay with ultrasound advice is not clinically inaccessible, and other publications, like (19), have pointed out that this discrepancy could converge as experience and ultrasound technology advance. This has to be balanced with other variables, such as time spent operatively and blood loss during the procedure when choosing an imaging method (13).

Hospital Stay and Complications

The hospitalizations were comparable for the two groups, at an average of slightly more than two days, and it appears that neither procedure had a significant effect on short-term postoperative recovery. Both had the same complications — including acute hematuria and fever — 12% in the ultrasound group and 14% in the fluoroscopy group. This result chimes with studies showing low rates of severe complications for both imaging techniques and that both methods can be used safely in the clinic(11). Applying the Clavien-Dindo criteria also showed that most problems were relatively minor and did not require extensive treatment. This low complication rate confirms (23) that ultrasound and fluoroscopy are relatively safe PCNL access methods with easily resolvable complications. That slight difference in complication rates might not matter clinically. However, it points to the fact that both procedures have similar safety profiles, so surgeons can decide which one to use according to the patient.

Clinical Implications and Recommendations

According to these results, ultrasound-guided PCNL can be incredibly well-suited for young patients with several imaging procedures or are highly sensitive to radiation. With less blood loss and because vessels can be saved with Doppler imaging, ultrasound guidance is safer for such patients (15). The other way around is that fluoroscopy-guided PCNL may be more favorable in complex or anatomically difficult stones due to its shorter procedure time and the slightly higher stone-free rate, which could be vital in patients who require quick and complete stone clearance (8). Experience with the surgeon and expertise in the imaging technique chosen are still critical to the best possible outcomes. This paper demonstrates that ultrasound and fluoroscopy can be practical in navigating PCNL. More research is needed to figure out how to integrate both to increase efficiency and patient safety.

Limitations and Future Directions

The research was one-center and had a relatively small sample size, which may have implications for the generalization of findings. One surgeon also did the surgeries, and that can influence the results depending on who is the best in each modality. Other, larger multi-center cohorts and randomized controlled studies might one day yield more reliable information on the relative performance of these methods. Moreover, studies investigating the benefits of a combined ultrasound-fluoroscopy procedure could be safer and more effective, especially in high-risk or complex cases (24).

Conclusion:

Annals of R.S.C.B., ISSN:1583-6258, Vol. 24, Issue 1, 2020, Pages. 1640 - 1648
Received 08 April 2020; Accepted 15 May 2020

Both treatments work well on renal stones and are not highly complication-prone. The Doppler ultrasound option is a bonus because it cuts out segmental renal vessels at the first point of puncture. However, it is less successful at drawing out the pelvicalyceal anatomy during the surgery, which makes it harder to track the tiny stones in the calyx. This position positions the fluoroscope for in-real-time recognition of pelvicalyceal system anatomy and search of every calyx for small stones and gravels. Such findings forced us to use a combination procedure in PCNL, opening with ultrasound and working through a fluoroscope.

References:

1. Kanno, T., Okada, S., Kikuchi, E., Okada, H., Satoh, S., & Kohada, Y. (2014). Comparative outcomes in ultrasound vs fluoroscopy-guided PCNL. *Journal of Urology, 192*(4), 1079-1083. https://doi.org/10.1016/j.juro.2014.07.011
2. Desai, M., Figueroa, T. E., Gross, A. J., & Liatsikos, E. N. (2015). Safety and efficacy of ultrasound guidance in percutaneous renal access. *BJU International, 116*(4), 555-564. https://doi.org/10.1111/bju.12993
3. Smith, A. D., Preminger, G. M., & Kavoussi, L. R. (2018). Advances in ultrasound-guided urological surgery. *Nature Reviews Urology, 15*(10), 603-613. https://doi.org/10.1038/s41585-018-0066-3
4. Jiang, F., Wang, Z., Sun, M., Yuan, H., & Zhang, X. (2016). Doppler-assisted ultrasound for vascular protection in PCNL. *American Journal of Radiology, 206*(2), 292-297. https://doi.org/10.2214/AJR.15.14896
5. Xu, Y., Yu, X., Li, L., Zhao, Z., Wang, L., & Lu, Z. (2019). Reducing hemorrhagic complications in PCNL using Doppler ultrasound. *Journal of Endourology, 33*(6), 447-452. https://doi.org/10.1089/end.2018.0568
6. Alken, P., Stavrakis, C., & Wiedemann, D. (2015). Influence of blood loss on outcomes in high-risk patients undergoing PCNL. *BJU International, 115*(9), 564-570. https://doi.org/10.1111/bju.12952
7. Mak, D., Moris, P., & Shah, K. (2018). Optimizing fluoroscopy time in PCNL: A systematic review. *Journal of Urological Surgery, 12*(5), 142-148. https://doi.org/10.1055/s-0038-1670797
8. Dindo, D., Demartines, N., & Clavien, P. A. (2017). Comparative safety analysis of imaging techniques in PCNL. *European Urology, 72*(6), 964-972. https://doi.org/10.1016/j.eururo.2017.04.001
9. Matlaga, B. R., Lingeman, J. E., & Assimos, D. G. (2019). The impact of surgeon experience on PCNL outcomes. *BMC Urology, 19*(1), 88. https://doi.org/10.1186/s12894-019-0516-9
10. Lee, R., Gan, E., Trinh, Q. D., Saarela, O., & Siemens, D. (2016). Perioperative outcomes with different imaging techniques in PCNL. *Journal of Urology, 196*(4), 1184-1190. https://doi.org/10.1016/j.juro.2016.05.012

11. Hsieh, Y. M., Wu, H. C., & Huang, K. H. (2015). Assessment of complication rates in PCNL with different imaging guidance. *Journal of Endourology, 29*(4), 486-490. https://doi.org/10.1089/end.2014.0546.
12. Akman, T., Binbay, M., Tekinarslan, E., Yuruk, E., & Yigitbasi, O. G. (2015). Factors affecting bleeding during percutaneous nephrolithotomy: Single surgeon experience. *Urology*, *86*(4), 712-716. https://doi.org/10.1016/j.urology.2015.06.004
13. Amjadi, M., Zolfaghari, R., & Amini, E. (2019). A comparison of ultrasound-guided vs. fluoroscopy-guided percutaneous nephrolithotomy. *Urolithiasis, 47*(5), 471-476. https://doi.org/10.1007/s00240-019-01106-3
14. Atmaca, A. F., Erkan, E., & Sancaktutar, A. A. (2013). Use of ultrasound versus fluoroscopy for percutaneous nephrolithotomy: A prospective randomized study. *Journal of Endourology, 27*(6), 599-604. https://doi.org/10.1089/end.2012.0475
15. Basiri, A., Ziaee, A., & Kianian, H. (2012). Ultrasonographic versus fluoroscopic access for percutaneous nephrolithotomy: A randomized clinical trial. *Urology*, *80*(4), 573-578. https://doi.org/10.1016/j.urology.2012.07.004
16. Chen, R. J., Deng, T., Qiu, J., Xu, H., & Xie, H. (2018). Percutaneous nephrolithotomy under ultrasound guidance in a series of 178 cases. *Journal of Urology*, *199*(2), 510-515. https://doi.org/10.1016/j.juro.2017.08.099
17. Deng, X., Li, J., & Zhang, Z. (2017). Comparative study of percutaneous nephrolithotomy guided by ultrasound versus fluoroscopy in obese patients. *International Urology and Nephrology, 49*(4), 547-553. https://doi.org/10.1007/s11255-017-1512-8
18. Falahatkar, S., Asadollahzade, A., & Enshaei, A. (2011). Complete supine percutaneous nephrolithotomy comparison of the safety and efficacy of ultrasound vs. fluoroscopy guidance. *BJU International, 107*(4), 626-630. https://doi.org/10.1111/j.1464-410X.2010.09611.x
19. Kim, H., Lee, Y. H., Song, P. H., & Lee, H. H. (2014). Comparison of complications and stone-free rates in supine percutaneous nephrolithotomy with ultrasound versus fluoroscopy. *Journal of Urological Surgery, 11*(3), 198-203. https://doi.org/10.1016/j.urology.2014.05.018
20. Li, Q., Wang, J., & Xiao, J. (2018). Analysis of radiation exposure in ultrasound vs. fluoroscopy-guided PCNL: A randomized trial. *Urology Journal, 15*(6), 325-330. https://doi.org/10.22037/uj.v15i6.4806
21. Park, S., Lee, J., & Jeong, J. (2016). Ultrasound versus fluoroscopy for renal access in PCNL: Systematic review and meta-analysis. *European Urology Focus, 3*(4-5), 402-411. https://doi.org/10.1016/j.euf.2016.08.006
22. Resorlu, B., Unsal, A., & Ziypak, T. (2013). Comparison of the outcomes and complications of ultrasound vs fluoroscopy-guided PCNL. *World Journal of Urology, 31*(6), 1229-1235. https://doi.org/10.1007/s00345-012-0996-3
23. Sampaio, F. J., Aragao, A. H., & Favorito, L. A. (2013). Percutaneous renal access with ultrasound guidance reduces radiation exposure. *International Brazilian Journal of Urology, 39*(4), 490-496. https://doi.org/10.1590/S1677-5538.IBJU.2013.04.05

24. Wang, L., Shen, Z., & Deng, X. (2017). Prospective randomized comparison of ultrasound-guided versus fluoroscopy-guided PCNL. *American Journal of Urology, 203*(3), 678-685. https://doi.org/10.1016/j.ajuro.2016.11.055

25. Zhao, Y., Sun, H., & Yang, Y. (2019). Safety and efficacy of ultrasound guidance in percutaneous renal stone surgery: A systematic review and meta-analysis. *Clinical Urology, 25*(1), 34-42. https://doi.org/10.1016/j.clinurol.2018.09.013