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Comparative Study of Outcome of Upper Pole Versus Non-Upper Pole Single Puncture Percutaneous Nephrolithotomy for Staghorn Stones

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Abstract

Percutaneous Nephrolithotomy (PCNL) is the treatment of choice for staghorn renal stones, either with an upper-pole (UP) or non-upper (lower or middle) pole (NUP) approach. Various studies have been sought to compare the outcomes of UP and NUP approach although results have not been entirely consistent. Hence, this study was designed to compare the outcome of two different renal access techniques on the stone-free rate of single puncture percutaneous nephrolithotomy. This Quasi-experimental study was conducted at the Department of Urology, Dhaka medical college Hospital, for a period of one year from January 2021 to December 2021. A total of 44 renal staghorn stone cases who underwent PCNL were included as study patients and were divided into two groups. Group-A (PCNL with UP calyceal approach) and Group-B (PCNL with NUP-middle or lower calyceal approach). Informed written consent was taken from each participant for operative procedure. Each patient was subjected to detail clinical evaluation along with history taking. Stone clearance was assessed by X-Ray KUB. Re-treatment if required for residual stones were done after 4 weeks. D-J stent was removed 4 weeks later. Collected data were analyzed by using the statistical software SPSS 24. The majority of the study participants from both the groups were from 45-54 years age (63.6% of Group A and 54.5% of Group B). There were no significant differences between groups in terms of demographic characteristics (age, sex, size of stone). The mean operation time was 73.45±6.52 (SD) minutes for the Group A and 76.05±5.18 (SD) minutes for Group B patients ($p>0.05$). The mean post-operative hemoglobin drop was 1.27±0.70 (SD) gm/dl for Group A and 1.32±0.47 (SD) gm/dl for Group B patients ($p>0.05$). Post-operative fever were developed in 22.7% Group A and 31.8% Group B patients ($p>0.05$). Complete stone clearance was achieved in 77.3% of Group A and 63.6% of Group B patients ($p>0.05$). Retreatment required for complete stone clearance after PCNL were 22.7% of Group A patients and 36.4% of Group B patients. Retreatment rate was higher in Group B patients but there wasn't any statistically significant difference between groups when compared ($p>0.05$). Percutaneous Nephrolithotomy for staghorn stones with single Upper pole access has similar stone free rate and complication rates compared to single non-upper polar approach.

Keywords: Percutaneous Nephrolithotomy (PCNL), Stone Clearance, Stone-Free Rate (SFR), Lower pole (LP) access, middle pole (MP) access, and upper pole (UP) access

Introduction

Urinary stone disease has been a persistent health issue affecting humans for centuries and remains a significant ailment worldwide, with a prevalence rate of 1-5% in Asia [1]. The lifetime prevalence is approximately 10% in men and 4% in women, often impacting individuals in their working years and contributing to a substantial socio-economic burden [2]. Staghorn stones, a specific type of kidney stone that fills the renal pelvis and part or all of the intrarenal calyceal system, can be complete or partial. They are usually unilateral and more commonly seen in females [3]. If untreated, these stones can lead to serious complications such as kidney function decline, end-stage renal disease, and life-threatening urosepsis [4]. Percutaneous nephrolithotomy (PCNL) has become the primary treatment for all types of renal stones due to its high success and stone-free rates, replacing open surgery over the past decades [5]. Advancements in PCNL techniques have aimed to enhance efficacy and safety in managing staghorn stones. PCNL can be performed using lower pole (LP), middle pole (MP), or upper pole (UP) access.

LP access is traditionally considered the safest due to its lower risk of bleeding and fewer thoracic complications like hydrothorax or pneumothorax [6]. Successful PCNL relies heavily on precise puncture and localization, often guided by fluoroscopy or ultrasound. However, achieving optimal puncture for large stones such as staghorn calculi can be challenging with standard imaging techniques, increasing the risk of intraoperative injuries [7]. LP access, while safer, may not achieve complete removal of staghorn stones. UP access, preferred for complex stones, is believed to improve stone-free rates due to better access to the intrarenal system, fewer punctures, and reduced manipulation damage [8-9].

The supra-costal UP approach facilitates comprehensive stone clearance, addressing infection and obstruction effectively [10]. PCNL was introduced in Bangladesh in 2000, with more widespread use at the National Institute of Kidney Disease and Urology starting in 2004, increasing familiarity among healthcare providers [11]. The success of PCNL depends on factors such as stone size, composition, and the spatial anatomy of the kidney [8].

Despite studies comparing UP and non-UP access approaches, there is limited research specifically evaluating single puncture PCNL outcomes for staghorn stones. Some research indicates shorter procedural times and minimal bleeding with LP access, while others show higher stone clearance rates with UP access. Yet, findings are not conclusive, and further investigation is needed to determine the optimal approach for single puncture PCNL. Establishing the most effective access approach could benefit urologists through improved outcomes and patients through reduced morbidity, shorter hospital stays, and financial savings. This study was designed to address the lack of regional research on this topic and contribute to better clinical practices.

Materials and Methods

This quasi-experimental study was conducted over a year (January to December 2021) at the Department of Urology, Dhaka Medical College Hospital, involving 44 patients diagnosed with staghorn renal stones and planned for PCNL. Patients were selected using purposive sampling and divided into Group A (UP calyceal approach) and Group B (NUP-middle/lower calyceal approach) based on allocation by lottery and alternate assignment. Detailed clinical evaluation, including history and physical examinations, was performed, and co-morbid conditions were optimized prior to surgery.

Under general anesthesia, a 6Fr ureteral catheter was positioned in lithotomy before switching to a prone position for percutaneous access. Calyceal puncture was performed using fluoroscopic guidance and confirmed by saline outflow. A safety guide wire was placed, followed by tract dilation with serial metallic dilators or a single fascial dilator up to 26 Fr. A 28Fr Amplatz sheath was inserted, and stone fragmentation was achieved using a 26 Fr nephroscope with a pneumatic lithotripter. Stone fragments were extracted via forceps or saline washing. The calyceal system was inspected for residual fragments, and a D-J stent was placed ante grade, with a 26 Fr nephrostomy tube inserted in all patients. Postoperatively, patients were monitored for vital signs, urine output, and temperature to assess fever. Hemoglobin levels were compared pre- and

post-operation. Stone clearance was evaluated via X-Ray KUB on the second postoperative day, with re-treatment planned after four weeks if needed. Patients were discharged on the fifth postoperative day if no complications arose, and D-J stent removal was scheduled four weeks post-surgery. Data were recorded on structured sheets encompassing clinical history, examination findings, and perioperative data. SPSS 24 was used for statistical analysis, with categorical variables presented as frequencies and percentages, and continuous variables as means and standard deviations. Associations were evaluated using chi-square tests, while independent t-tests assessed differences between continuous variables, with significance set at $p < 0.05$. The study received ethical approval, and informed consent was obtained from participants, ensuring confidentiality and the right to withdraw at any time.

Results

Table 1: Distribution of patients according to age, sex and stone location between groups (N=44)

Variable	Group A (N=22)	Group B (N=22)
Age	25-34	7(31.8%)
	35-44	6(27.3%)
	45-54	9(40.9%)
	Mean \pm SD	39.64 \pm 9.32
Sex	Male	14(63.6%)
	Female	8(36.4%)
Stone location	Rt kidney	12(54.5%)
	Lt kidney	10(45.5%)

This study assessed and compared perioperative outcomes, complications, and overall efficacy between patients undergoing PCNL using upper pole (UP) access (Group A) and non-upper pole (middle/lower) access (Group B). The mean age of participants was nearly identical, with 39.64 \pm 9.32 years for Group A and 39.27 \pm 7.81 years for Group B, indicating similar demographic distributions. The stone location predominantly affected the right kidney in both groups (54.5% in Group A and 63.6% in Group B). Operative time did not differ significantly between groups, averaging 73.45 \pm 6.52 minutes for Group A and 76.05 \pm 5.18 minutes for Group B ($p > 0.05$). Preoperative hemoglobin levels were comparable (14.00 \pm 1.69 g/dL for Group A and 14.18 \pm 1.74 g/dL for Group B), and postoperative hemoglobin drops (1.27 \pm 0.70 g/dL in Group A and 1.32 \pm 0.47 g/dL in Group B) did not significantly differ ($p > 0.05$). Blood transfusion requirements were slightly higher in Group A (18.2%) compared to Group B (13.6%), but this difference was not statistically significant. Hydrothorax/pneumothorax was noted only in 9.1% of Group A patients due to the supracostal puncture route, while Group B reported none. Fever/sepsis incidence was higher in Group B (31.8%) than in Group A (22.7%), though not significantly different ($p > 0.05$). Stone clearance rates favoured Group A (77.3%) over Group B (63.6%), with Group B showing a higher need for retreatment at 36.4% compared to 22.7% in Group A. Despite these differences, the statistical significance for stone clearance and retreatment between the groups was not observed ($p > 0.05$). Both groups had similar postoperative hospital stays, with Group A averaging 4.68 \pm 1.13 days and Group B 4.77 \pm 1.27 days. A majority (59.1% in Group A and 54.5%

in Group B) required hospitalization for ≥ 5 days. Overall, while UP access showed advantages in stone clearance and access, it was associated with higher risks of complications like hydrothorax/pneumothorax. However, these were

manageable, suggesting that both approaches can be effectively used depending on the clinical scenario and patient risk factors.

Table 2: Distribution of respondents according to comparison between groups (N=44)

Operation time(minutes)	Group A (N=22)	Group B (N=22)	P-Value, t-test
Mean \pm SD	73.45 \pm 6.52	76.05 \pm 5.18	0.152
Hemoglobin level (in gm/dl), (Mean \pm SD)			P-Value, t-test
Pre-operative	14.00 \pm 1.69	14.18 \pm 1.74	0.727
Post-operative	12.73 \pm 1.52	12.86 \pm 1.93	0.796
Post-operative Hb drop	1.27 \pm 0.70	1.32 \pm 0.47	0.803
Complications			P-Value, Chi-square test
Blood transfusion required	4 (18.2%)	3 (13.6%)	0.680
Hydrothorax/pneumothorax	2 (9.1%)	0 (0.0)	0.073
Fever/sepsis	5 (22.7%)	7 (31.8%)	0.498
Complete stone clearance achieved after PCNL			P-Value, Chi-square test
Yes	17 (77.3%)	14 (63.6%)	0.322
No	5 (22.7%)	8 (36.4%)	
Retreatment required after PCNL			P-Value, Chi-square test
Yes	05 (22.7%)	08 (36.4%)	0.319
No	17 (77.3%)	14 (63.6%)	
Hospital stay (in days)			P-Value, t-test
Mean \pm S D	4.68 \pm 1.13	4.77 \pm 1.27	0.803
Hospital stay category (in days)			P-Value, Chi-square test
< 5 days	9 (40.9%)	10 (45.5%)	1.0
≥ 5 days	13 (59.1%)	12 (54.5%)	

*p-value < 0.05 is considered significant.

Discussion

The treatment of complex staghorn calculi presents significant challenges and requires careful selection of surgical approaches to ensure the best outcomes. The present study conducted at DMCH compared the outcomes of PCNL performed with upper pole (UP) and non-upper pole (middle/lower) access, involving 44 patients divided evenly between these two groups.

In this study, the majority of participants in both groups were within the 45-54 years age category, with 40.9% from each group represented. The mean age for patients undergoing PCNL with UP access was 39.64 \pm 9.32 years, while for those with non-UP access, it was 39.27 \pm 7.81 years, showing no statistically significant difference ($p > 0.05$). This finding is consistent with Singh *et al.* (2015)^[8], where the mean ages for UP and non-UP groups were 39.84 \pm 10.42 and 39.553 \pm 10.23 years, respectively, with no significant differences noted. These similarities reinforce the notion that age does not substantially influence the choice between UP and non-UP access (Singh *et al.*, 2015)^[8]. This study reported a predominance of male patients in both groups, with 63.6% male in the UP access group and 55% male in the non-UP access group. Contrastingly, studies by Netto *et al.* (2005)^[12] indicated an equal gender ratio for patients undergoing PCNL with UP access and a higher representation of females in the non-UP group. Akagashi *et al.*, 2004^[13] also observed an equal male-to-female ratio for staghorn stones. These differences could be attributed to demographic variations or sample sizes, suggesting that gender distribution may vary by region.

The mean operative time for UP access was 73.45 \pm 6.52 minutes, compared to 76.05 \pm 5.18 minutes for non-UP access, with no significant difference between the groups ($p > 0.05$). While this study did not observe a significant variance, Singh *et al.* (2015)^[8] reported longer durations for UP access procedures. Conversely, found that lower/middle access required more time (139.1 minutes) compared to UP

access (134.9 minutes). The efficiency of the UP approach may be explained by superior visualization through the upper calyx, facilitating faster and more thorough stone removal.

The current study reported blood transfusion rates of 18.2% for UP access and 13.6% for non-UP access, without significant differences ($p > 0.05$). These findings align with Netto *et al.* (2005)^[12], where 12.5% of patients in the UP-access group required transfusions versus 14.3% in the non-UP group. Notably, complications such as hydrothorax/pneumothorax were more common in the UP-access group (9.1%) due to the supracostal approach, a finding supported by research from Sukumar *et al.* (2008) and Kukreja *et al.* (2004)^[14-15], who identified higher thoracic complications associated with supracostal punctures. Fever/sepsis was observed in 22.7% of patients with UP access and 31.8% with non-UP access. However, the length of hospital stay was nearly identical between the groups, with means of 4.68 \pm 1.13 days for UP access and 4.77 \pm 1.27 days for non-UP access, consistent with Singh *et al.*, 2015 and Blum *et al.*, 2018^[8, 16]. These similarities suggest that both approaches have comparable postoperative recovery durations.

Complete stone clearance was achieved in 77.3% of patients in the UP-access group versus 63.6% in the non-UP access group, though the difference was not statistically significant ($p > 0.05$). Netto *et al.*, 2005^[12] reported higher clearance rates of 87.5% for UP access and 80% for non-UP access, highlighting the general advantage of UP access due to its direct path and effective visualization of the renal system (Oner *et al.*, 2018)^[17]. Retreatment rates were higher in the non-UP group (36.4%) compared to the UP group (22.7%), yet no significant difference was detected. Singh *et al.*, 2015^[8] similarly reported higher ancillary procedure needs in non-UP approaches. The comparative analysis demonstrates that while UP access in PCNL may involve higher risks of thoracic complications, it provides superior visualization

and access, facilitating more efficient stone clearance. The findings align with existing literature, which emphasizes the benefits of UP access despite its potential complications [12, 18]. The choice of approach should balance the risk of complications against the potential for better outcomes, with recent evidence indicating that complications related to UP access are decreasing and often manageable [18].

Conclusion

In conclusion, while both UP and non-UP PCNL approaches for staghorn calculi demonstrate similar rates of success, complications, and recovery times, the UP approach generally offers better stone clearance due to superior access and visualization. Although it carries a higher risk of thoracic complications, these are often manageable and have decreased in recent years. Overall, the UP approach can be considered a preferred method for complex cases, provided that risks are carefully managed to maximize patient outcomes

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