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Comparative Evaluation of the Upper and Lower Calyceal Approaches in Percutaneous Nephrolithotomy for the Treatment of Staghorn Calculus

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Abstract

Background: Branched stones called staghorn calculi make up most of the pelvicalyceal system. For staghorn calculi, percutaneous nephrolithotomy (PCNL) is currently the recommended first-line treatment option. Optimal renal access is critical to PCNL success.

Objective: to compare between lower and upper calyceal PCNL approaches for treating staghorn calculus at the renal pelvis and/or lower calyx.

Methods: PCNL was performed on 40 patients with complex renal stones in our center. Twenty had a lower calyceal puncture, and 20 had upper calyceal access. The two methods are compared in terms of the overall duration of the procedure, the requirement for a second puncture, the success rate (residual stone presence), intraoperative blood transfusion rates, postoperative complication rates, and hospital stay.

Results: The mean operative time in lower access was 64.5±23.73 min which was longer than that of upper group (50.5±18.88 min) with a significant. Compared to none in the upper calyceal approach, five patients (20%) in the lower approach require a secondary puncture. Two patients (10%) in the upper access experienced pneumothorax versus one patient (2%) in the lower access experienced angioembolization. There is no difference in the duration of hospital stays between the two methods.

Conclusion: The upper calyceal approach, with minimizes lung complications and requires a short surgical time, is a feasible option for pelvic and/or lower calyceal renal calculi.

Keywords: Percutaneous nephrolithotomy, staghorn, lower and upper calyceal approach.

Introduction :A large stone that occupies multiple branches of the collecting system in the kidney's renal pelvis is referred to as a staghorn (1). These stones are typically unilateral (2). Female gender, extreme age ranges, congenital urinary tract malformations, urine stasis, urine diversion, neurogenic bladder, indwelling Foley catheters, distal renal tubular acidosis, medullary sponge kidney, and diabetes mellitus are risk factors that predispose patients to these stones (3). Timely diagnosis and treatment are essential for staghorn stones due to their significant morbidity and potential for mortality.

Large renal stones can now be treated with minimal invasion through percutaneous nephrolithotomy (PCNL). PCNL is regarded as a generally safe management option with a low incidence of complications thanks to advancements in techniques and equipment (4,5). PCNL is

now the recommended for patients with kidney calculi bigger than 2 cm. Additionally, it is particularly helpful when extracorporeal shockwave lithotripsy fails, in patients with unfavorable lower calyceal anatomy, and those with large (>2 cm) lower calyceal calculi (6,7).

The optimal approach for PCNL management of calyceal stone is to enter the desired calyx directly; however, this direct entry may be linked to undesirable complications such as pleural and lung injury, hydrothorax, pneumothorax, and slippage passage through the lower calyx in prone PCNL (8). However, because there are some anatomical differences between the supine and prone positions when using this approach, there is now another option that involves reaching it through the lower calyx in the supine position with greater accessibility and better manipulation (9,10).

The present study aimed to compared upper and lower calyceal PCNL in the current study to treat staghorn calculus in the renal pelvis and/or lower calyx.

Methods

Study design : This is a prospective comparative single center study including 40 consecutive patients diagnosed with renal calculi and scheduled for PCNL in Al-Nasiriyah Teaching Hospital during the period from January to December 2023. Patients with any pelvic calculus and/or inferior calyceal calculi were eligible for the study. On the other hand, patients with, isolated middle calyceal calculi or stones in calyceal diverticula, those with history of coagulopathies, morbid obesity, and congenital urinary tract anomalies were exclude from the study. After a thorough history and clinical examination, all patients underwent renal ultrasound, X-ray KUB, NCCT, and blood investigations (complete blood count (CBC), renal function test, serum electrolytes and coagulation profile), urine microscopy and urine culture. The local health committee approved the study, and each patient signed a written informed consent form.

Study groups and data collection : Case selection for upper or lower calyceal access was decided at time of operations based on findings of the intrarenal anatomy on retrograde pyelogram. The general guideline for selecting an access site, as articulated by Lingeman et al. (11), was followed to determine the desired calyx: percutaneous access to the kidney that enable maximum stone removal with a rigid nephroscope. Accordingly, patients were divided into two groups according to surgical management: 20 patients managed by the upper calyceal approach, and 20 patients managed by lower calyceal approach. Demographic characteristics including age, sex, affected site, and stone size were collected form all patients before operation.

Surgical Technique : The both groups of patients with renal stones managed by PCNL . To delineate the renal collecting system with contrast material, a cystoscopy and the insertion of a 6Fr ureteral catheter are the first steps.

The upper and lower calyceal approaches were performed between the paraspinal and posterior axillary lines. Every upper calyceal supracostal puncture was performed at the mid-scapular line, in the 11th intercostal space. The puncture site was lateral to mid-scapular line in obese patients.

Skin and subcutaneous punctures were performed during the expiratory phase of supracostal punctures, while deep inspiration was used for renal parenchymal punctures.

The free passage of urine through the needle and the proper positioning of the Teremo guidewire served as indicators of a successful calyceal puncture. Alken's metal dilator system was used to dilate the initial tract up to 24Fr, and an amplatz sheath was then introduced. Stones were broken up using a Pneumatic Lithoclast, and a rigid nephroscope (Stortz 24 Fr).

Following fragmentation and stone removal, direct nephroscopy and fluoroscopy were used to check for any remaining stones in the collecting system. In every instance, nephrostomy placement and antegrade Double-J stenting are carried out.

Patients undergoing upper calyceal supracostal punctures had their chest pain, dyspnea, tachypnea, and clinically reduced air entry closely monitored during the postoperative phase. A postoperative chest X-ray was performed on all patients who underwent upper calyceal supracostal punctures. If necessary, intercostal drainage was scheduled due to possible thoracic complications. On day one post-operatively, hemoglobin was measured and a KUB X-ray was performed on all patients.

The operation's duration, complete clearance, hemoglobin drop, need for a blood transfusion, the subsequent procedure needed, sepsis and fever, length of hospital stay, and success rate were all considered. Defined full clearance was defined as the absence of a radio-opaque shadow on the postoperative X-ray KUB or a residual stone size of less than 4 mm on the postoperative ultrasonography/CT. If the postoperative hemoglobin level falls below 8 g/dl, a blood transfusion is given.

Operative time, secondary puncture required, residual stone and blood transfusion were recorded during the operation. Patients were followed up for one month after operation during which the hospital stay and postoperative complication were reported.

Statistical analysis : The Statistical Package for Social Science (SPSS) version 25 computer program was used to tabulate and analyze these data. For quantitative data, descriptive statistics were computed as mean and standard deviation; for qualitative data, they were computed as frequency and distribution. When comparing the means of two sets of quantitative data statistically, the t-test was used to determine the significance of the difference, and the Chi-square test (χ2-value) was used to categorical variables. A p-value of less than 0.05 was considered significant.

Results

Preoperative characteristics of the patients : There was no significant disparity between the patients' mean ages for the upper and lower calyceal PCNL approaches, 47.45±15.93 years and 45.95±17.62 years, respectively. Similarly, there was no discernible difference between the two subgroups about sex, affected side, or stone size (Table 1).

Table (1): Preoperative characteristics of the patients

Variables	Percutaneous Nephrolithotomy		P-Value
	Upper Approach (N= 20)	Lower Approach (N=20)	
Age, Years			
Mean±SD	**47.45±15.93**	**45.95±17.62**	**0.746**
Range	**25-71**	**31-68**	
Sex			
Male	**13(65%)**	**11(55%)**	**0.519**
Female	**7(35%)**	**9(45%)**	
Affected Side			
Right	**8(40%)**	**11(55%)**	**0.342**
Left	**12(60%)**	**9(45%)**	
Stone Size, Mm			
Mean±SD	**4.46±2.19**	**4.73±2.17**	**0.687**
Range	**1.5-9.0**	**1.8-8.5**	

Intraoperative characteristics of the patients : There was a significant difference in the mean operative time between the PCNL upper access (50.5±18.88 min) and the lower calyceal PCNL approach (64.5±23.73 min). Additionally, there was a significant difference between the number of patients who required a secondary puncture in PCNL lower access (20%) compared to PCNL upper approach (none). On the other hand, although the difference was not statistically significant, individuals using the PCNL lower approach had more residual stones and required blood transfusions than those using the PCNL upper approach (Table 2).

Table (2): Intraoperative characteristics of the patients

Variables	Percutaneous Nephrolithotomy		P-Value
	Upper Approach (N= 20)	Lower Approach (N=20)	
Operative Time, Min			
Mean±SD	**50.5±18.88**	**64.5±23.73**	**0.046**
Range	**25-90**	**40-110**	
Secondary Puncture Required			
No	**20(100%)**	**15(75%)**	**0.035**
Yes	**0(0%)**	**5(25%)**	
Residual Stone			
No	**2(10%)**	**4(20%)**	**0.661**
Yes	**18(90%)**	**16(80%)**	
Blood Transfusion			
No	**19(95%)**	**16(80%)**	**0.151**
Yes	**1(5%)**	**4(20%)**	

Postoperative complications : Two different complications were noted. Out of the patients who underwent PCNL upper approach, two patients (10%) experienced pneumothorax, and one patient (5%) underwent angioembolization. Statistically, postoperative complications did not significantly differ between the two groups (Figure 1).

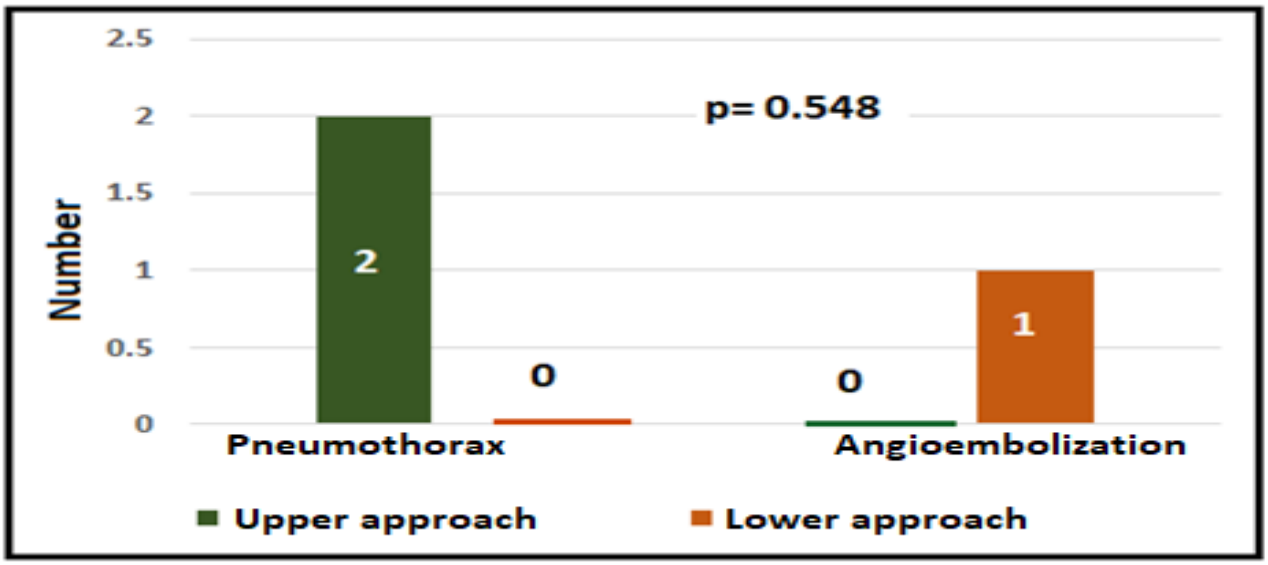

Figure (1): Postoperative complication in patients with pelvic and/or lower calyceal renal calculi undergoing upper and lower calyceal access.

Hospital stay : The mean hospital stay for patients with PCNL upper approach was 2.31±0.64 days compared to 2.78±0.82 days with PCNL lower approach, with no significant difference (Figure 2).

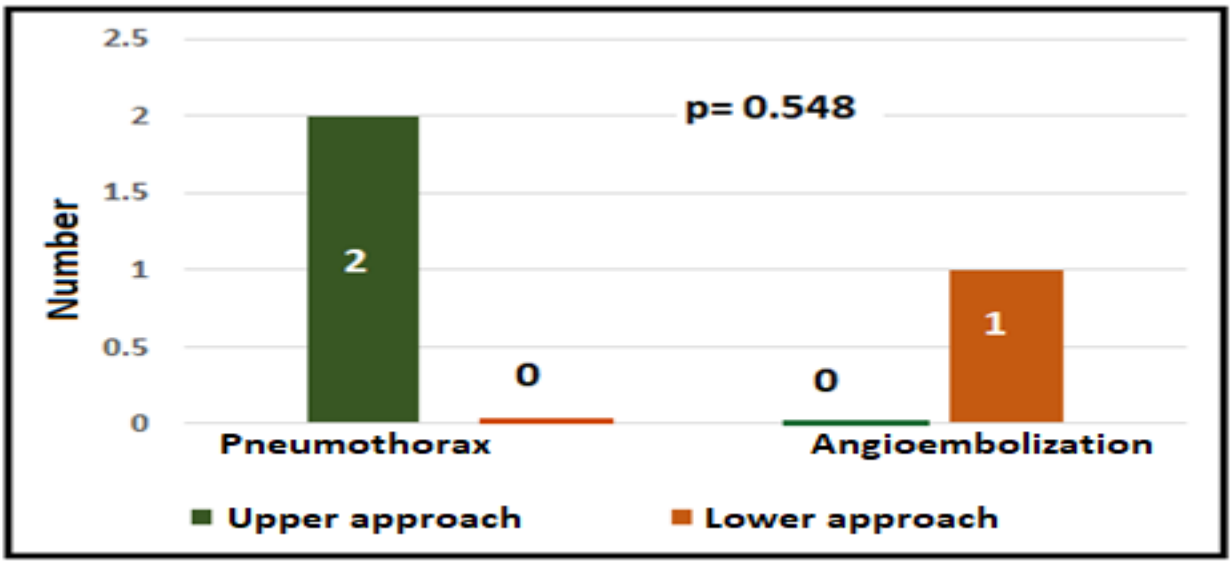

Figure (2): Hospital stay in patients with pelvic and/or lower calyceal renal calculi undergoing PCNL upper and lower calyceal access

Discussion

When kidneys with large stone burdens undergo PCNL, optimal clearance depends on carefully choosing an ideal access tract. Numerous studies have been done to date comparing the effectiveness of upper and lower calyceal punctures in obtaining the greatest clearance with the fewest possible side effects. To treat small renal stones, percutaneous nephrolithotomy was introduced in the 1970s. The development of ultrasonic and electrohydraulic lithotripters made it easier for them to play a subsequent role in the treatment of staghorn stones (12).

In the present study, the mean operative time was significantly shorter in upper than the lower approach. This is consistent a meta-analysis including 16 studies with 8,541 individuals. The pooled results suggested that upper approach offers shorter operative time (13). In a similar study, Amaresh et al. (14) compared the efficiency of upper and lower calyceal PCNL approaches for treating staghorn calculus in 126 Turkish patients. The study revealed that the operative time was in favor of upper approach.

Numerous other studies have demonstrated that the difference in operating time is caused by the additional time needed to reposition the patient in a prone position, regardless of the size or location of the stone or the approach (22, 23). In contrast, Singh et al. (17) discovered no distinction in the time of the surgery between the two methods.

This discrepancy could be attributed for several factors, the most important of which are the stone characteristic and anatomical variation.

In the present study, secondary puncture was required for 25% of patients in lower approach versus none in the upper approach with a significant difference. This goes in line with study of Amaresh et al (14) who found that a second puncture was required in one patient in upper approach and n 5 patients in lower approach (p= 0.004). Also Ma et al. (13) demonstrated that upper approach associated with less additional punctures compared with other approaches.

In fact, in the lower approach, slippage, bending and kinking of the guidewire is sometimes seen when passed through the percutaneous puncture needle. This leads to guidewire dislodgement and displacement with a consequence of performing second puncture.

In the present study, upper calyceal access offered 10% fewer failed stone clearances than the lower calyceal group (20%) although the difference was no significant. Many authors reported similar findings when using an upper calyceal approach in their investigations (15,18,19).

In the present study, access to many calyces was easy when one approaches the upper calyx, which facilitates effective nephroscope and forceps manipulations within the pelvicalyceal system. When a tract was established through the lower calyx, this was not the case, necessitating excessive angulation and torque. This difference may be attributed to the anatomical location of the kidney over the iliopsoas muscle and the straight tract of the upper infundibulum along the kidney's long axis may, with the upper pole positioned more posteriorly than the lower pole. When one approaches via the upper calyx, these two factors offer excellent visualization of the pelvicalyceal system.

In the present study, only one patient experienced a thoracic complication during the upper calyceal approach. This is consistent with the finding of Singh et al. (17) that only 1 out of 21 patients experienced subclinical hydrothorax, identified by a postoperative chest X-ray.

Nonetheless, the occurrence was lower than the 3% to 16% that other researchers had documented (20,21). Anatomically, the parietal pleura crosses the posterior middle rib of the 12th rib and the posterior axillary line of the 11th rib. It creates a safe zone with little chance of pleural damage from the 11th intercostal space lateral to the mid-scapular line. It is possible that the upper technique of puncturing the skin and subcutaneous tissue during expiration, while also puncturing the renal parenchyma during inspiration (for adequate renal descent) makes upper calyceal access at the 11th intercostal space at/lateral to the mid-scapular line safe, minimizing the risk of thoracic complications.

Regarding the need for a blood transfusion, there was significant difference between the two subgroups (1 for the upper versus 4 for the lower calyceal approach). Singh et al. reported similar results (17). Blood transfusion rates during PCNL typically range from 0% to 20% (22,23).

Similar to the findings of Ma et al.'s study (13), no difference in hospital stays was observed between the two approaches in our research. Also, in accordance with the present result is the study of Amaresh et al. (14) who did not found a significant difference between the two approaches in term of hospital stay. This indicate that both approach is safe with very few complications.

The current study is limited by its relatively small patient population, which can be attributed to the stringent upper calyceal stone selection criteria.

Collectively, these data indicate that upper calyceal access in PCNL is associated with shorter operative time, fewer rate of additional punctures, lower postoperative complication rates decrease in the complications. Therefore, this approach could be the first choice unless contraindicated.

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