RESEARCH ARTICLE

# Upper, middle, and lower CALYX accesses for prone percutaneous nephrolithotomy: a comparative study

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## Abstract

**Objective:** To compare upper, middle and lower calyceal accesses for prone percutaneous nephrolithotomy regarding stone-free rates, residual stones, haemoglobin drop and fluoroscopic time.

**Method:** The prospective comparative clinical study was conducted from September 2018 to March 2021 at Al-Yarmouk Teaching Hospital, Baghdad, Iraq, and comprised patients of either gender aged 18-78 years with renal stones treated with percutaneous nephrolithotomy. They were divided into three groups on the basis of calyx access: upper calyx G1, mid-calyx G2, and lower calyx G3. Procedure-related parameters, such as fluoroscopic time, stone-free rates and haemoglobin drop, were analysed in detail. Patients were followed up within 1-week post-surgery through complete blood count, ultrasound and computerised tomography. Data was analysed using SPSS 27.

**Results:** Of the 151 patients with a mean age of 46.01±14.7 years, 89(58.9%) were males and 62(41.1%) were females. There were 63(41.7%) patients in G1, 38(25.2%) in G3 and 50(33.1%) in G3. The diameter of renal stones ranged from 20-60mm. There were 45(71.4%) patients with stone-free outcome in G1, 22(57.9%) in G2 and 37(74%) in G3 (p>0.05). There was no significant difference in the mean haemoglobin drop among the groups (p>0.05).

**Conclusions:** No significant intergroup difference was observed in terms of access in the sequelae regarding residual stone and haemoglobin drop.

**Key Words:** Nephrolithotomy, Percutaneous, Blood Cell, Hemoglobins, Tomography

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## Introduction

Renal stone disease is a highly prevalent condition. European guidelines currently recommend percutaneous nephrolithotomy (PNL) for renal stones in patients with >20mm total stone diameter [1, 2]. It has a better stone-free rate (SFR) compared to flexible ureteroscopy or shock wave lithotripsy[3].

The creation of renal access is the hallmark in the success of PNL[4, 5]. The choice of calyx for access is usually dictated by retrograde pyelogram.

Puncture into the upper calyx provides the most versatile access to the pelvis, proximal ureter and lower pole. This site often requires sacricostal access above the 12th rib, and increases the risk of pleural violation and blood loss [6]. Nonetheless, if sacricostal access is indicated, it should be used with caution[7]. Middle pole calyceal access is a forgotten site; it offers ready access, particularly for renal pelvis stone, but the torquing effect during navigation for the upper or lower pole calyces is a drawback[8].

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Since the lower pole calyx provides larger access to the kidney, it is the most preferable site utilised by urologists as it eliminates the possibility of pulmonary morbidity associated with upper pole access[9].

The current study was conducted to compare the upper, middle and lower accesses in PNL for SRF, fluoroscopic time and drop in haemoglobin level.

## Patients and methods

The prospective comparative clinical study was conducted from September 2018 to March 2021 at Al-Yarmouk Teaching Hospital, Baghdad, Iraq.

Approval from an ethical review committee (ERC) and ensuring informed consent from the participants were obtained. The sample size was calculated using the Epi-Info equation.[10] and the sample was raised using simple random sampling technique. Those included were patients of either gender aged 18-78 years having stone size >20mm who had a single-port procedure. Patients aged <18 years, those with a history of renal surgery, active urinary tract infection, multiple tract accesses and congenital anomalies, such as horseshoe kidney, mal-rotated kidney and calyceal diverticulum, were excluded. After consent was obtained from all the patients, they were divided into three groups on the basis of calyx access: upper calyx G1, mid calyx G2, and lower calyx G3. Stone size, age, gender, residual stones, mean drop of haemoglobin (Hb) and fluoroscopic exposure time were noted.

The indication for PNL was stone size >2cm in diameter, calculated by taking the longest diameter in computerised tomography (CT).

Pre-operatively, the patients were assessed by urinalysis and urine culture. Pre- and post-operative Hb levels were checked in addition to medical status obtained from electrocardiogram (ECG), chest X-ray (CXR) and viral serology. Moreover, a polymerase chain reaction (PCR) test was done for coronavirus disease-2019 (COVID-19) for cases enrolled after the pandemic outbreak in 2020. A pint of compatible blood was prepared pre-operatively for all the patients.

For PNL intravenous (IV) antibiotics and general endotracheal anaesthesia or spinal anaesthesia were administered. A ureteric catheter 6Fr. was inserted through a rigid cystoscope and 14Fr. Foly's catheter was inserted into the bladder. Both catheters were secured with tape into the right or left thigh according to the site of the stone. The patient was positioned in a prone with two chest rolls. A retrograde pyelogram was performed through the ureteric catheter to delineate the collecting system and renal pelvis. An 18G diamond-tipped needle was employed for puncturing by using the bull's eye technique. A hydrophilic guidewire was used, either coiled inside the pelvicalyceal system or passed into the ureter under fluoroscopic guidance. Using a scalpel blade No.11, a 1cm stab incision in the skin was made. Serial dilators (telescopic dilators) were inserted over guide rode thereafter for which a 30Fr. or 26Fr. Amplatz sheath was used. Subsequently, a 24Fr. nephoscope was used. The stone(s) was/were fragmented using pneumatic lithotripsy. An antegrade JJ stent was inserted with the aid of fluoroscopy. However, double J stent was not used in patients who were found to be stone-free on intraoperative fluoroscopic screening. The nephrostomy catheter 12Fr. or 14Fr. was fixed to the skin with a silk suture, and the nephrostomy was closed. Later the same day, the presence of any haematuria was examined and opened 6 hours post-operatively. The nephrostomy catheter was removed on day 1 post-operatively. The patients were followed up after one week and one month post-operatively. Success was defined as stone-free outcome or an insignificant residual stone <4mm in diameter on follow-up. Complications were assessed using the Clavien-Dindo classification.[11]

Data was analysed using SPSS 27. Comparisons were done using Pearson's chi-square test with the application of Yate's correction or Fisher's exact test, whenever applicable. P<0.05 was considered significant.

## Results

Of the 151 patients with mean age 46.01±14.7 years, 89(58.9%) were males and 62(41.1%) were females. There were 63(41.7%) patients in G1, 38(25.2%) in G2 and 50(33.1%) in G3. The diameter of renal stones ranged from 20-60mm. Only hydronephrosis values were significantly different among the groups (p<0.05). There were 45(71.4%) patients with stone-free outcome in G1,

**Table-1:** Baseline patient characteristics and stone data.

| | Upper | | Mid | | Lower | | P value |
|---|---|---|---|---|---|---|---|
| | No | % | No | % | No | % | |
| **Age (years)** | | | | | | | |
| Mean±SD | 46.3±13.4 | | 45.4±13.4 | | 47.3±12.8 | | 0.801 |
| (Range) | (18-78) | | (20-73) | | (18-70) | | |
| **Gender** | | | | | | | |
| Male | 33 | 52.4 | 22 | 57.9 | 34 | 68.0 | 0.243 |
| Female | 30 | 47.6 | 16 | 42.1 | 16 | 32.0 | |
| Stone diameter (mm) | | | | | | | |
| Mean±SD | 30.79±11.11 | | 30.84±10.12 | | 30.10±9.73 | | 0.925 |
| (Range) | (20-60) | | (20-55) | | (18-60) | | |
| **Stone site** | | | | | | | |
| Right | 27 | 42.9 | 12 | 31.6 | 21 | 42.0 | 0.492 |
| Left | 36 | 57.1 | 26 | 68.1 | 29 | 58.0 | |
| **Opacity** | | | | | | | |
| Left | 36 | 57.1 | 26 | 68.1 | 29 | 58.0 | 0.770 |
| Lucent | 22 | 34.9 | 16 | 42.1 | 19 | 38.0 | |
| Opaque | 41 | 65.1 | 22 | 57.9 | 31 | 62.0 | |
| Anaesthesia | | | | | | | |
| Spinal | 33 | 52.4 | 20 | 52.6 | 21 | 42.0 | 0.480 |
| GA | 30 | 47.6 | 18 | 47.4 | 29 | 58.0 | |
| **Double J** | | | | | | | |
| Yes | 49 | 77.8 | 30 | 78.9 | 36 | 72.0 | 0.694 |
| No | 14 | 22.2 | 8 | 21.1 | 14 | 28.0 | |
| **Hydronephrosis** | | | | | | | |
| No | 10 | 15.9 | 8 | 21.1 | 13 | 26.0 | 0.020 |
| Mild | 43 | 68.3 | 18 | 47.4 | 18 | 36.0 | |
| Moderate | 10 | 15.9 | 9 | 23.7 | 14 | 8.0 | |
| Sever | - | - | 3 | 7.9 | 5 | 10.0 | |
| **Fluoroscopic time (minutes)** | | | | | | | |
| Mean±SD | 1.98±0.79 | | 2.10±1.15 | | 2.12±1.24 | | 0.754 |
| (Range) | (1.00-5.00) | | (1.00-5.50) | | (1.00-6.00) | | |
| **Hb drop (g/dL)** | | | | | | | |
| Mean±SD | 1.08±0.33 | | 1.09±0.59 | | 0.97±0.37 | | 0.317 |
| (Range) | (0.30-1.80) | | (0.40-3.10) | | (0.50-2.60) | | |
| **Outcome** | | | | | | | |
| Free | 45 | 71.4 | 22 | 57.9 | 37 | 74.0 | 0.230 |
| Residual | 18 | 28.6 | 16 | 42.1 | 13 | 26.0 | |

*Significant difference between percentages using Pearson Chi-square test ($\chi$2-test) at 0.05 level.
^Significant difference among more than two independent means using ANOVA-test at 0.05 level.
SD: Standard deviation, Hb: Haemoglobin, GA: General anaesthesia,

**Table-2:** Calyceal accesses and its complications assessed using Clavien-Dindo classification.

| Complications | Upper | | Mid | | Lower | | P value |
|---|---|---|---|---|---|---|---|
| | No | % | No | % | No | % | |
| I | 36 | 57.2 | 24 | 63.2 | 32 | 64.0 | 0.423 |
| II | 27 | 42.8 | 14 | 36.8 | 18 | 36.0 | |
| III | - | - | - | - | - | - | |
| IV | - | - | - | - | - | - | |
| V | - | - | - | - | - | - | |

22(57.9%) in G2 and 37(74%) in G3 (p>0.05). There was no significant difference in the mean Hb drop among the groups (p>0.05). (Table 1).

In terms of complications, there was no significant difference among the groups (Table 2).

## Discussion

A successful PNL achieves the removal of stones with minimum risk to the patients. Puncturing the calyx is an important step to access the stone, avoiding the need for second access. Selecting suitable calyceal access is usually determined after obtaining the retrograde pyelogram.

In the current study, there were 58.9% male patients and 41.1%) female patients. Male predominance can be explained by the increasing effect of testosterone on oxalate metabolic pathway, leading to the high incidence of calcium oxalate stone[12, 13].

More than half of the patients (62.2%) had radiopaque renal stones. Ozgor et al. showed 87% radiopaque stones [14]. The higher percentage of lucent stones in the current study is related to the fact that Iraq has a hotter climate which is more likely to cause uric acid stone[15].

The upper calyx access was the most common site (41.7%), followed by lower (33.1%) and middle (25.2%). Upper calyx access was preferred for staghorn stones because it permits access to the upper ureter, renal pelvis and other calyces[16]. The main issue of upper calyx access is the high rate of pulmonary and pleural complications[17].

The current study observed that upper calyx access was more dilated in comparison to other calices in cases of obstructive pelvic stone, and, therefore, access, passing the guide wire, and dilatation was easier than in other calices.

The current study had 57.1% of patients accessed through the upper calyx from the left side compared to 14% reported earlier[18].

Regarding residual stone in G1, the current study found that the upper calyx access residual (28.6%) was slightly higher than that in the lower calyx group (26%). This was in agreement with a larger study data that compared single access, lower and upper calyx access in 4,494 cases [16].

The classical PNL access was mostly performed through the upper or lower accesses, while the mid-calyx access was rarely used. Recently, clinicians have started to choose the middle calyx[8, 19]. Middle calyx access was utilised in 25.2% of the current patients. This was the lowest proportion compared to the other groups, while stone residual was the highest (42.1%) in the middle group compared to the upper (28.6%) and lower (26%) groups. This was contradictory to the finding of S. Yan et al. who recorded the highest SFR in the middle calyx access group[8].

Blood loss and Hb drop-in percutaneous stone surgery can occur during needle passage, tract dilation and nephrostomy. The postoperative mean Hb drop in the current study was 1.09g/dl for the middle access group. This slightly higher drop of Hb might be attributed to more torquing of the nephoscope towards the stone that led to the infundibular injury. The finding was nearly similar to Sanjay Khadgi et al. (1.1%) [19], though they used mini-PNL in their study.

Lower calyx access is preferred by many urologists because of the lower morbidity rates of subcostal punctures. However, on many occasions it is not easy to pass the guide-wire to the pelvis because of the angle between the lower calyx and pelvis is an acute one. In the current study, 33.1% patients were accessed through the lower calyx. The mean stone diameter (30.1mm) and mean age (47.3 years) were comparable to other groups. Mean Hb drop (0.97 g/dl) was the lowest among the groups due to less vascularity of the lower calyx than the others. Fluoroscopic time to reach the stone was the highest (2.12min) in G3 compared to the other groups. This could be explained by slippage or improper positioning of the guide-wire during passage which made dilatation cumbersome for lower calyceal access. The finding is in agreement with that of Amaresh et al[20].

## Conclusion

No significant difference was observed among upper, middle and lower access group in the sequelae regarding residual stone, Hb drop and fluoroscopic time. Proper site selection of access in PNL should be tailored according to the patient, stone factors and experience of the operating surgeon.

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