RESEARCH ARTICLE

Comparative evaluation of upper versus lower calyceal approach in percutaneous nephrolithotomy (PCNL) for managing renal calculi

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Abstract

Objective: To compare upper versus lower calyceal approaches in percutaneous nephrolithotomy for managing renal calculi.

Method: The retrospective study was conducted in the Department of Urology, The Kidney Centre Post-Graduate Training Institute, Karachi, and comprised data of patients who underwent percutaneous nephrolithotomy from January 2014 to January 2015. Patients were divided into upper pole puncture group A and lower pole puncture group B. Data was analysed using SPSS 17.

Results: Of the 198 patients, 147(74.2%) were males and 51(25.8%) were females. The overall mean age was 40.64±14.02 years. Of the total, 69(34.84%) were in group A and 129(65.15%) were in group B. Inter-group difference was significant in pre- and post-operative haemoglobin ($p<0.05$). Post-operative outcomes showed that blood transfusion, stone clearance and complication like tube thoracostomy had significant association with both the groups ($p<0.05$). Complete clearance was seen in 152(76.8%) patients; 40(74.1%) in group A and 102(81.6%) in group B.

Conclusion: The success rate was found to be better in lower calyceal puncture group than upper calyceal puncture group for the management of renal calculi.

Keywords: Upper and lower calyceal approach, Percutaneous nephrolithotomy, Renal calculi. (JPMA 71: 602; 2021)
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Introduction

Renal calculi are treated effectively today with percutaneous nephrolithomy (PCNL)[1] which is harmless with a success rate of >90%.[2] However, the success is greatly dependent upon clear visual examination that aids in direct access for the manipulation of stones.[3] Research shows that in <25% cases there is haemorrhage and <15% cases report intrathoracic and other organ injuries with percutaneous renal surgery.[2,4]

The effectiveness of PCNL is subjective to renal calyceal approach. There is reported failure rate when approaching from lower calyx and injury is reported to kidney parenchyma.[2,5] With reported intra-thoracic and pleural complications in supracostal approach, it is preferred to approach subcostally in PCNL[6,7] whereas in some cases, like the presence of stone in the upper calyx, impacted upper ureteral stones and visualising ureteropelvic junction, it is always preferred to approach supracostally. Ideally, it is effective to approach through superior calyx when managing complex upper and lower calyceal calculi.[8] whereas when stones are present in the inferior calyx, the posterior inferior calyx approach is made.[2] The upper pole of the kidney is medial and posterior to the lower pole. This anatomy makes the upper pole a shorter and easier access route.[4] Unfortunately, greater rate of complications are reported in supracostal puncture group cases.[2,3]

The current study was planned to compare the upper versus lower calyceal approach of PCNL in terms of efficacy and complications for managing renal calculi.

Patients and Methods

The retrospective study comprising secondary data analysis was conducted in the Department of Urology, The Kidney Centre Post-Graduate Training Institute, Karachi, and included data of patients who underwent PCNL from January 2014 to January 2015. The sample was raised using non-probability convenience sampling technique irrespective of age and gender. Patients with urinary tract infection (UTI), bleeding diathesis, pulmonary disease, morbid obesity, and end-stage renal disease (ESRD) were excluded.

Patient demographics, stone size and previous history of open renal surgery were documented retrospectively. Patients were divided into upper pole puncture group A and lower pole puncture group B. Each patient underwent PCNL under general anaesthesia, and was operated upon

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by a team of urologists. Cystoscopy was carried out after which 4.5FR ureteral catheter was inserted. The patient was then turned to a prone oblique position. Under fluoroscopic guidance, the desired calyx was chosen for access keeping in mind that maximum stone removal was to be achieved via percutaneous access using a rigid nephroscope.

Proper calyceal puncture was confirmed by free flow of contrast agent through the puncture needle and delineation of collecting system without extravasation of contrast and appropriate placement of guide-wire. Where another puncture was needed in order to have full clearance, another puncture was made, the second guide-wire was passed and the tract was dilated with serial metallic dilator as in the first puncture. After fragmentation with eighter pneumatic or combined pneumatic-ultrasound lithoclast and stone removal, direct nephroscopy and fluoroscopy was carried out for residual stones. Antegrade or retrograde double J stenting (DJS and nephrostomy placement was done in selected cases.

Patients with upper calyceal supracostal punctures had post-operative chest X-ray done. Haemoglobin (Hb) was checked and X-ray kidney-ureter-bladder (KUB) was done on the first post-operative day for all patients.

The procedure was evaluated in terms of operative time, complete clearance, Hb drop, blood transfusion required, secondary procedure required, sepsis, hospital stay and success rate. Complete clearance was considered to have been achieved if the post-operative X-ray KUB showed no radio-opaque shadow or the residual stone size was <4mm on post-operative ultrasonograph / computed tomography (USG/CT) scan. Blood transfusion was given if the post-operative Hb dropped <8g/dl. The success rate was defined as the number of patients achieving complete clearance after PCNL.

Data was entered into Microsoft Excel 2007 and was analysed using SPSS 17. Frequency and percentages for categorical variables and mean and standard deviation for continuous variables were calculated. Statistical inference was obtained by t-test for the difference between any two values, and chi-square test was used to see the association between variables. Statistical significance was set at $p \leq 0.05$.

Table-1: Comparison of mean difference among upper and lower pole groups.

		Overall (n=198)	Upper Pole (n=69)	Lower Pole (n=129)	p Value
Age (years)	Mean ± SD	40.64±14.02	42.03±14.50	39.90±13.75	0.310**
	Range	65.00	62.00	63.00	
	Minimum	13.00	13.00	15.00	
	Maximum	78.00	75.00	78.00	
	Median (IQR)	40.00 (21.0)	40.00 (17.0)	40.00 (24.0)	
	95% CI (LL-UL)	38.68 - 42.61	38.55 - 45.51	37.50 - 42.30	
Size of Stone (cm)	Mean ± SD(cm)	3.25±1.13	3.42±1.08	3.17±1.15	0.139**
	Range	5.40	5.00	5.00	
	Minimum	1.50	1.90	1.50	
	Maximum	6.90	6.90	6.50	
	Median (IQR)	3.00 (1.70)	3.20 (1.50)	2.90 (1.80)	
	95% CI (LL-UL)	3.10 - 3.41	3.16 - 3.68	2.97 - 3.37	
Pre-Operative Hb (gm/dl)	Mean ± SD	13.15±1.76	12.76±1.84	13.36±1.69	0.022*
	Range	8.30	6.90	8.20	
	Minimum	9.30	9.30	9.40	
	Maximum	17.60	16.20	17.60	
	Median (IQR)	13.30 (2.63)	12.70 (3.20)	13.60 (2.50)	
	95% CI (LL-UL)	12.91 - 13.40	12.32 - 13.20	13.07 - 13.66	
Post-Operative Hb (gm/dl)	Mean ± SD	11.52±1.65	11.20±1.82	11.69±1.53	0.044*
	Range	6.90	6.90	6.80	
	Minimum	8.00	8.00	8.10	
	Maximum	14.90	14.90	14.90	
	Median (IQR)	11.45 (2.70)	11.10 (2.80)	11.50 (2.45)	
	95% CI (LL-UL)	11.29 - 11.75	10.76 - 11.63	11.42 - 11.96	
Residual Stones(mm)	Mean ± SD	0.29±0.45	0.32±0.49	0.28±0.42	0.489**
	Range	3.0	3.00	1.50	
	Minimum	0.00	0.00	0.00	
	Maximum	3.00	3.00	1.50	
	Median (IQR)	0.00 (0.50)	0.00 (0.70)	0.00 (0.50)	
	95% CI (LL-UL)	0.23 - 0.36	0.20 - 0.44	0.20 - 0.35	

* Significant at 0.05 levels. ** Not Significant at 0.05 levels. SD: Standard deviation; IQR: Interquartile range; CI: Confidence interval; LL: Lower level; UL: Upper level; Hb: Haemoglobin.

Table-2: Frequency and association of preoperative findings in upper and lower pole groups.

		Overall (n=198) n (%)	Upper Pole (n=69) n (%)	Lower Pole (n=129) n (%)	p Value
Gender	Male	147(74.2%)	51(73.9%)	96(74.4%)	0.938**
	Female	51(25.8%)	18(26.1%)	33(25.6%)	
Diabetes Mellitus	Yes	26(13.1%)	10(14.5%)	16(12.4%)	0.678**
	No	172(86.9%)	59(85.5%)	113(87.6%)	
Hypertension	Yes	47(23.7%)	21(30.4%)	26(20.2%)	0.105**
	No	151(76.3%)	48(69.6%)	103(79.8%)	
Chronic Renal Failure	Yes	2(1.0%)	2(2.9%)	0(0%)	0.120**
	No	196(99.0%)	67(97.1%)	129(100%)	
Hepatitis	Yes	7(3.5%)	3(4.3%)	4(3.1%)	0.696**
	No	191(96.5%)	66(95.7%)	125(96.9%)	
Number of Stones	Single	130(65.7%)	29(42.0%)	39(30.2%)	0.096**
	Multiple	68(34.3%)	40(58.0%)	90(69.8%)	
Radiopaque	Yes	191(96.5%)	66(95.7%)	125(96.9%)	0.696**
	No	7(3.5%)	3(4.3%)	4(3.1%)	
Radiolucent	Yes	7(3.5%)	3(4.3%)	4(3.1%)	0.696**
	No	191(96.5%)	66(95.7%)	125(96.9%)	
Sides	Right	100(50.5%)	38(55.1%)	62(48.1%)	0.024*
	Left	95(48.0%)	28(40.6%)	67(51.9%)	
	Bileteral	3(1.5%)	3(1.5%)	0(0%)	
Urine C/S	Positive	17(8.6%)	7(10.1%)	10(7.8%)	0.567**
	Negative	181(91.4%)	62(89.9%)	119(92.2%)	
Pelvic Stone	Yes	128(64.6%)	42(60.9%)	86(66.7%)	0.416**
	No	70(35.4%)	27(39.1%)	43(33.3%)	
Staghorn	Yes	49(24.7%)	22(31.9%)	27(20.9%)	0.089**
	No	149(75.3%)	47(68.1%)	102(79.1%)	
PCNL Side	Right	95(48.0%)	37(53.6%)	71(55.0%)	0.245**
	Left	103(52.0%)	32(46.4%)	58(45.0%)	
Puncture	Bulls Eye	54(27.3%)	41(59.4%)	13(10.1%)	0.0.000+++
	Parallex	125(63.1%)	12(17.4%)	113(87.6%)	
	Both	19(9.6%)	16(23.2%)	3(2.3%)	
PCNL with URS	Yes	4(2.0%)	2(2.9%)	2(1.6%)	0.612**
	No	194(98.0%)	67(97.1%)	127(98.4%)	
PCNL with DJS	Yes	52(26.3%)	27(39.1%)	25(19.4%)	0.003+++
	No	146(73.7%)	42(60.9%)	104(80.6%)	

+++ Significant at 0.01 levels * Significant at 0.05 levels ** Not Significant at 0.05 levels
C/S: Culture and sensitivity; PCNL: Percutaneous nephrolithotomy; URS: Ureterorenoscopy; DJS: Double-J stent.

Results

Of the 198 patients, 147(74.2%) were males and 51(25.8%) were females. The overall mean age was 40.64±14.02 years. Of the total, 69(34.84%) were in group A and 129(65.15%) were in group B. Of the total, 26(13.1%) patients were diabetic, 47(23.7%) were hypertensive, 2(1.0%) had chronic renal failure (CRF), and 7(3.5%) were positive for hepatitis B or C. Radiopaque stone was observed in 191(96.5%) patients and radiolucent stone was observed in 7(3.5%) patients. Overall, 130(65.7%) patients had single stone and 68(34.3%) had multiple stones (Figure-1). Also, 100(50.5%) patients had stones on the right side, 95(48.0%) on the left side and 3(1.5%) had stones on bilateral sides (Figure-2). Inter-group difference was significant in pre- and post-operative Hb level, but there was no significant difference in terms of mean age and size of stone (Table-1).

The pre-operative urine culture was still positive in 17(8.6%) patients after treatment and therefore PCNL with done under appropriate peri-antibiotic cover. Further, 8(4%) patients went into sepsis, and 1(12.5%) of them died. Pelvic stone was present in 128(64.6%) cases and staghorn in 49(24.7%) (Table-2).

In terms of post-operative outcomes, blood transfusion had a significant association with both the groups ($p<0.05$),

Table-3: Frequency and association of postoperative findings between upper and lower pole groups.

		Overall (n=198) n (%)	Upper Pole (n=69) n (%)	Lower Pole (n=129) n (%)	p Value
Redo PCNL	Yes	3(1.5%)	1(1.4%)	2(1.6%)	1.000**
	No	195(98.5%)	68(98.6%)	127(98.4%)	
Blood Transfusion	Yes	14(%7.1)	11(15.9%)	3(2.3%)	
	No	184(92.9%)	58(84.1%)	126(97.7%)	
Complete clearance	Yes	152(76.8%)	40(74.1%)	102(81.6%)	
	No	46(23.2%)	14(25.9%)	23(18.6%)	

+++ Significant at 0.01 levels * Significant at 0.05 levels ** Not Significant at 0.05 levels
PCNL: Percutaneous nephrolithotomy.

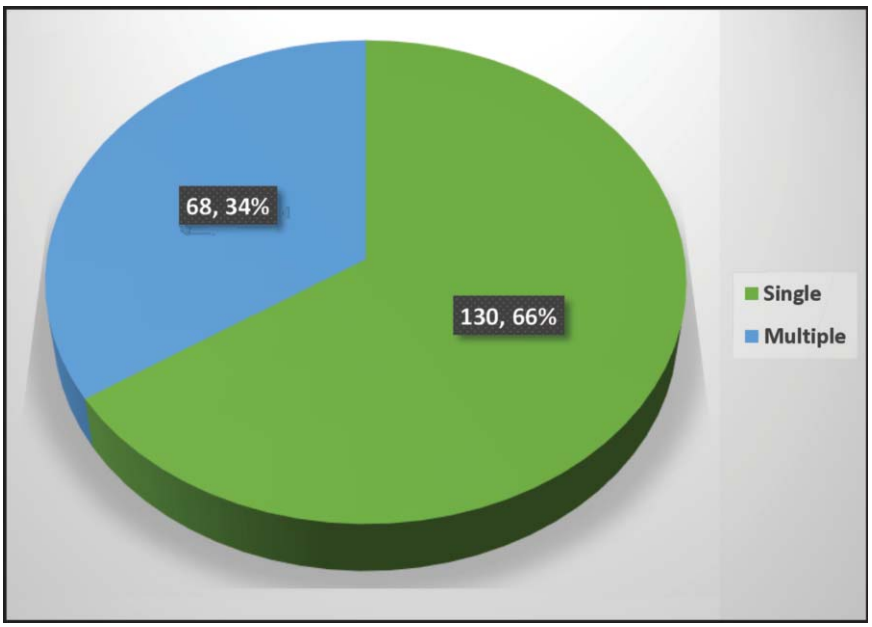

Figure-1: Overall percentage of number of stones.

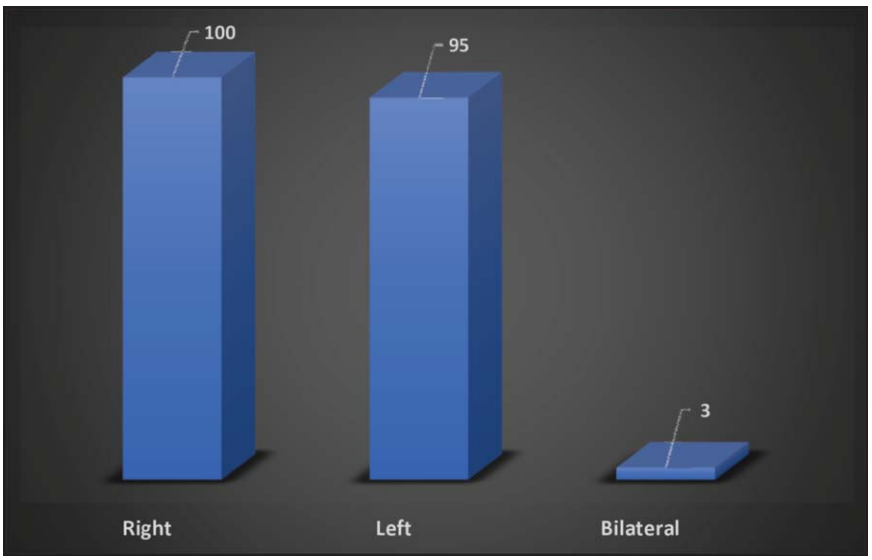

Figure-2: Frequency of side of stones.

while redo PCNL had no significant association (p>0.05). Complete clearance was observed in 152(76.5%) patients; 40(74.1%) in group A and 102(81.6%) in group B (Table-3).

Overall, 6(3%) patients developed hydrothorax. Of them, 5(83.3%)in group A, and 3(60%)needed tube thoracostomy. The rest of the patients were treated conservatively.

Discussion

PCNL is also known for treating large renal mass.[9] The percutaneous approach is mostly the preferred technique today. Despite being a challenging technique, it is still preferred by most urologists.[6] It is highly effective when the approach is made through the proper tract. Stones are removed when the puncture of upper pole is carried out through posterior calyx, but, with lower pole access, bleeding and trauma have been reported in patients.[10]

One of the benefits for accessing through pole is its direct and straight tract in the kidney that provides clear visualisation of surrounding parts inside the kidney[11,12] whereas supracostal approach is also known as the superior calyceal approach.[3]

A study said PCNL was effective in removing almost 85% of staghorn stones with only 5% intra-thoracic complications and 2% requiring chest tube.[3] In another study, patients required transfusion due to loss of blood.[6] Other studies have reported

similar results.[1,13,14] In the current study, blood transfusion was required in 14 cases among which 11 were in the upper pole group and 3(2.3%) in the lower pole group.

Studies have reported the length of hospital stay ranging from 3 days to 608 days.[1,6,14-17]

Literature reported success in stone removal using PCNL to be 75%.[5,18] The current study had overall complete clearance in 152(76.5%) cases; 81.6% in lower and 74.1.3% in upper pole puncture group. Patients who needed multiple puncture were 19, and their clearance was lower at 52.6%.

One study had success rate of 90.70% in upper calyceal group patients, whereas it was 76% in lower calyceal group.[2] We found easier accessibility to many calyces when an approach was made through the upper calyx. In the case of lower calyx, undue angulation and torque were noted. This difference was probably due to the straight tract in the infundibulum and the anatomy of iliopsoas muscle. In a study with 21 patients who underwent upper calyceal supracostal puncture, only 1 patient developed subclinical hydrothorax diagnosed on post-operative chest X-ray.[2]

In another study, there was no statistical significance between the type of puncture and blood-loss.[6] However, when the amount of blood loss was evaluated between patients having past medical history of open kidney surgery and intra-operative pelvi-calyceal tear, there was significant blood-loss seen in the upper calyceal puncture group compared to the lower calyceal group.[6] This can be explained due to the injury caused to the upper infundibulum either during puncture to upper calyx or excessive torque during intrarenal manipulations leading to upper infundibular tear. One study[19] stated that infundibular arteries were involved in 87% cases, while 62% cases were not involved with arteries. In another study[20] there was 75% inter-lobal vessel injury. In the current study, only 1 patient needed angio-embolisation which was included in the lower pole puncture group, but more significant blood transfusion was needed in the upper pole puncture group.

The main complications cited in both groups in literature include fever and sepsis.[6,21,22]

Conclusion

The success rate was found to be better in lower calyceal puncture group compared to the upper calyceal puncture group for the management of renal calculi. The safety of both the punctures was different with a better efficacy of lower calyceal puncture. Though the upper pole remains a preferable option due to easy access, significant chest complication may occur. Lower pole access provides better clearance rates with acceptable complications.

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