Middle calyx access in complete supine percutaneous nephrolithotomy

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Cite as: *Can Urol Assoc J* 2013;7(5-6):e306-10. http://dx.doi.org/10.5489/cuaj.11307
Published online May 13, 2013 (early released July 16, 2012).

Abstract

Background: Middle calyx access has been underused in percutaneous nephrolithotomy (PCNL), especially in the supine position. We compared the safety and efficacy outcomes between middle calyx and lower calyx accesses in the complete supine PCNL in a non-randomized single-surgeon clinical study.

Methods: Between February 2008 and October 2011, 170 patients underwent posterior subcostal single tract complete supine PCNL with one-shot dilation and middle calyx (n = 48) and lower calyx (n = 122) accesses. Stone location and surgeon decision determined target calyx for access. Inclusion criteria were pelvis stones, staghorn stones and multiple location stones. Exclusion criteria were renal anomalies, only upper calyx stones, only middle calyx stones and only lower calyx stones. Important parameters were compared between the two groups. A p value of <0.05 was considered significant.

Results: Two groups were similar in important patient- and stone-related parameters. Mean operative time (60.7 minutes), mean postoperative hospital stay (1.84 days) and mean hemoglobin drop (0.67 g/dL) in the middle calyx group were significantly lesser than in the lower calyx group (80.1 minutes, 2.19 days, 1.36 g/dL). The middle calyx group (89.6%; 79.6%) had a higher stone-free rate ($p = 0.054$) and efficiency quotient than the lower calyx group (76.2%; 61.6%). In the middle calyx group (10.4%; 2.1%), complication and transfusion rates were lesser ($p > 0.05$) than lower calyx group (14.8%; 7.4%). No significant difference ($p = 0.40$) was seen between two groups using the modified Clavien classification of complications.

Interpretation: Middle calyx can be an optimal access in PCNL with the complete supine position for many of upper urinary tract stones due to its superior outcomes.

Introduction

Today, percutaneous nephrolithotomy (PCNL) is the suitable minimally invasive procedure for many upper urinary tract stones.[1-6] PCNL is usually performed in the prone position.[7] Compared with prone PCNL, supine PCNL is an appropriate method due to convenience of patient and surgeon, lack of patient re-position for intubation and catheterization, proper control of airway, simultaneous accomplishment of ureteroscopy and PCNL, lower pressure of the collecting system and easier evacuation of stone fragments, shorter operative time and similar outcomes.[7-10] Convenient insertion of a percutaneous tract is necessary to successfully remove the stone. Access to the collecting system is performed via upper, middle and lower calices.[11-15] Upper calyx access provides a perfect reach to the collecting system and many upper tract stones. However, this access may incur intrathoracic complications.[4,12,14-17] Moreover, multiple tracts may be necessary for successful treatment. Lower calyx access is used particularly for lower calyx stones, with minimal risk of intestinal injury.[11,12] In some cases, single lower calyx access may be a difficult approach for reaching renal calices and for completely removing stones due to the sharp angles between the calices. It may lead to increased operative time, incomplete removal of stones and the need for additional access or subsequent ESWL in complex lower calyx stones.[5,11,12,18]

Middle calyx access has been underused in PCNL, especially in the supine position.[11-18] Whereas middle calyx seems appropriate to access stones in the upper tract.[13,19] In this non-randomized single-surgeon study, we compared the safety and efficacy outcomes between middle calyx and lower calyx accesses in patients with complete supine PCNL.

Methods

Between February 2008 and October 2011, we evaluated patients who underwent complete supine PCNL with middle calyx and lower calyx accesses. Intravenous urography, ultrasonography and computed tomography scan (as needed) were used for preoperative imaging. Antibiotic prophylaxis was performed in all patients before the operation. All PCNLs were accomplished by a single surgeon.

In the complete supine position, patients were laid at the edge of the bed and had neither flank elevation nor changes in their leg situation during the PCNL. Stone location and surgeon decision determined the target calyx for access and this selection was not randomized. Fluoroscopy and ultrasonography were used to obtain access and guidance in 84.1% and 15.9% of cases, respectively. Cystoscopy and retrograde ureteral catheter insertion, posterior subcostal access, one-shot dilation (9Fr dilator, 28F Amplatz dilator), 30F Amplatz working sheath and pneumatic lithotripsy were applied in all operations. Nephrostomy tube was inserted, as necessary. At the end of the operation, all patients were screened by fluoroscopy or ultrasonography for probable residual fragments. A stone-free result was considered if kidneys-ureters-bladder (KUB) radiography and ultrasonography showed no residual stone or insignificant residual stone fragments <4 mm on postoperative day one.

Inclusion criteria were pelvic stones, staghorn stones and multiple location stones. Multiple location stones were defined as stones in two or more locations of the upper urinary tract (upper calyx, middle calyx, lower calyx, pelvis, upper ureter). Exclusion criteria were renal anomalies, only upper calyx stones, only middle calyx stones and only lower calyx stones. Also excluded were patients with single calyx stones who underwent PCNL with the same calyx access. Only 22 patients underwent multiple tract accesses and were excluded from study. Also one patient with simultaneous stones in the lower calyx diverticula and the renal pelvis was excluded. Finally, a total of 170 patients were included (48 with middle calyx access and 122 with lower calyx access). Our ethical committee approved this research.

Important patient-, stone- and operation-related parameters were collected and compared between the two groups. Analysis was performed by Student-t, Mann-Whitney, Chi-square and Fisher's exact tests using SPSS version 16.0 (SAS Institute Inc., Cary, NC). A p value of <0.05 was considered statistically significant.

Results

The mean age, male-to-female ratio and mean body mass index (BMI) were 52.8±10.2 years (range: 32-75), 28:20 and 30.0±4.4 kg/m^2 in the middle calyx group; and 47.0±11.9 years (range: 20-78), 68:54 and 27.9±4.9 kg/m^2 in the lower calyx group. No significant differences were seen in gender, BMI, diabetes mellitus, previous stone surgery and extracorporeal shock wave lithotripsy (ESWL), stone opacity, stone multiplicity and side, staghorn and multiple location stones between the two groups. The mean preoperative serum creatinine was 1.32±0.80 (range: 0.8-6.3) and 1.12±0.79 (range: 0.6-8.8) mg/dL in the middle calyx and lower calyx groups, respectively. There were no significant differences between the two groups in the mean preoperative hemoglobin (13.64±1.16 vs. 13.25±1.76 g/dL; p = 0.11) and mean stone burden (37.16±13.60 vs. 34.40±14.16 mm; p = 0.25) (Table 1).

Type of anesthesia, imaging for access and tubeless approach were not statistically different between the two groups. Mean operative time and mean postoperative hospital stay in the middle calyx access group (60.7±40.9 minutes; 1.84±0.82 days) were significantly (p = 0.002; p = 0.005) shorter than in the lower calyx access (80.1±43.8 minutes; 2.19±0.65 days). The stone-free rate was 89.6% and 76.2% in middle and lower calyx groups, respectively (p = 0.054). Mean postoperative hemoglobin was 13.00±1.55 and 11.92±1.72 g/dl in middle calyx and lower calyx accesses respectively and this difference was significant (P<0.001). Middle calyx access (0.67±0.91 g/dl) had significantly (P<0.001) lesser mean hemoglobin drop than lower calyx access (1.36±1.31 g/dl) (Table 2).

The complication rate was 10.4% and 14.8% in middle and lower calyx access groups, respectively (p = 0.46). Some patients had more than one complication. The differences in the transfusion rates were not significant (2.1% and 7.4%, in the middle and lower calyx groups, respectively) (p = 0.28). Three patients (6.2%) with middle calyx access and 7 patients (5.7%) with lower calyx access experienced low-grade fever (p = 1.00), with the mean duration of 1.33±0.58 (range: 1-2) and 2.14±0.69 (range: 1-3) days, respectively. The fever was secondary to atelectasis and was self-resolved in all patients, without the need for antibiotics, intensive care or secondary intervention. Self-limited postoperative gross hematuria occurred in 1 patient (2.1%) with middle calyx access and in 1 patient (0.8%) with lower calyx access, which was treated conservatively. Moreover, 3 patients (2.46%) with lower calyx access experienced delayed gross hematuria, clot retention and ureteral obstruction 7 to 10 days after the operation, which required the removal of clots and a double-J stent placement. The mean follow-up duration was 24.4±13.3 months in patients with gross hematuria (early or delayed) and these patients did not require surgical intervention or angioembolization. There were no intra-thoracic complications in both groups. No significant difference (p = 0.40) was seen between the two groups in the modified Clavien classification[20] of complications (Table 2).

The mean follow-up duration was 25.7±12.4 (middle calyx access: 19.6±8.8; lower calyx access:28.1±12.8) months. Ultrasonography and KUB x-ray were applied for the assessment 2 weeks after the operation. All patients with insignificant residual fragment <4 mm became free of stone without secondary intervention. One patient (2.1%) with middle calyx access underwent repeated PCNL and subsequent ESWL for significant residual fragment. Also, repeated PCNL was performed in one patient (0.8%) with lower calyx access and significant residual fragment. Other

Table 1. Patient- and stone-related parameters in middle calyx and lower calyx accesses

Parameter	Middle calyx access	Lower calyx access	*p* value
Patients, n	48	122	-
M/F ratio, n (%)	28 (58.3%)/20 (41.7%)	68 (55.7%)/54 (44.3%)	0.76
Mean BMI (SE; range), kg/m²	30.0±4.7 (0.63; 20.37-41.01)	27.9±4.9 (0.46; 19.1-46.71)	0.18
Groups of BMI			
BMI <25 kg/m²	16.7%	29.5%	
BMI 25-29.9 kg/m²	45.8%	41%	0.21
BMI ≥30 kg/m²	37.5%	29.5%	
Mean preoperative hemoglobin (SE; range), g/dL	13.64±1.16 (0.17; 9.7-15.8)	13.25±1.76 (0.16; 9.6-18.0)	0.11
Diabetes mellitus, n (%)	11 (22.9%)	18 (14.8%)	0.20
Previous stone surgery, n (%)	11 (22.9%)	32 (26.2%)	0.65
Previous ESWL, %	37.5%	44.2%	0.39
Mean stone burden (SE), mm	37.16±13.60 (1.96)	34.40±14.16 (1.28)	0.29
Opacity of stone: Radio-opaque/ radiolucent, %	81.3%/18.7%	86.1%/13.9%	0.55
Multiplicity of stone: Single/multiple, %	33.3%/66.7%	23%/77%	0.23
Staghorn stone, n (%)	8 (16.7%)	16 (13.1%)	0.55
Multiple location stones, n (%)	30 (62.5%)	70 (57.4%)	0.54
Stone side: R/L, n (%)	21 (43.8%)/27 (56.2%)	64 (52.5%)/58 (47.5%)	0.33

M: male; F: female; BMI: body mass index; SE: standard error of the mean; ESWL: extracorporeal shock wave lithotripsy; R: right; L: left.

patients with significant residual fragment were managed by ESWL 6 weeks after the operation. The efficiency quotient was 79.6% and 61.6% for the middle and lower calyx access, respectively.

Discussion

Target calyx for access may affect PCNL outcomes.[11-15] Upper calyx access is in the direction of the longitudinal axis of the renal pelvis and provides optimal sight from the upper pole to the lower pole and directly reaches the upper calyx, renal pelvis, uretero-pelvic junction and proximal ureter.[11,12,14,16] However, the risk of intra-thoracic complication increases with this access.[11,16,17] Since subcostal upper calyx access may be difficult, the intercostal or supracostal approach is often used, yet this increases the risk of intra-thoracic complications.[11] A single percutaneous tract is sufficient during lower calyx access to remove a single lower calyx stone. But complete removal of complex or multiple lower calyx stones may be difficult by single lower calyx tract,[11,12,18] therefore upper calyx access is beneficial in these cases.[12] Although Li and colleagues[13] reported their experiences in PCNL with the middle calyx puncture, middle calyx has been underused for access in comparison with upper calyx and lower calyx, especially in the supine position.[11,12,14-18,21] Middle calyx access provides a suitable removal of stones, especially upper ureteral stones, due to proper alignment with the uretero-pelvic junction.[4,19]

We used the complete supine position in all PCNLs. The complete supine PCNL is suitable for all patients with upper urinary tract stones and has a shorter operative time than prone PCNL.[9,10]

In reports by Nishizawa and colleagues[11] and Li and colleagues,[13] the mean operative time was 129.5 and 78 minutes with lower calyx and middle calyx accesses, respectively. For complex lower calyx stones, Aron and colleagues reports mean operative times of 48 minutes and 74 minutes in the upper and lower calyx access, respectively.[12] For staghorn stones, Netto and colleagues report mean operative times of 86.8 and 139.1 minutes in upper pole and middle/lower calyx accesses, respectively.[14] Also for staghorn stones, Wong and colleagues report mean operative times of 2.9 hours and the upper calyx access/total access ratio was 35/45.[15] Shalaby and colleagues report mean operative times of 80 minutes for branched stones and 49.1 minutes for multiple stones with lower calyx access.[21] Compared with lower calyx access (80.1 minutes) and other studies,[11-15,21] the middle calyx access (60.7 minutes) reported in our study is fitting. Moreover, in our study middle calyx access (89.6%) had a higher stone-free rate than lower calyx access (76.2%). The stone-free rate has been reported from 63.3% to 89% with different calyx accesses in other studies.[11-14,21]

It may result from easy access to the middle calyx, proper angle between the middle calyx tract and long axis of the kidney, optimal alignment of this access with uretero-pelvic junction and easy access to the renal pelvis and upper ureter for removal of stones.[4,19] Traditionally, upper and lower calices are used for access. The acute angle between lower calyx tract and long axis of the kidney may difficulty in some cases. In these instances, middle calyx access can reduce time and surgeon fatigue. Target calyx for access is predictive in PCNL operative time.[22] Middle calyx access has a shorter operative time than other calices accesses.[22] Access to the main burden of the stone is an important factor during PCNL. In lower calyx access, Amplatz sheath and rigid nephroscope are usually placed under the inferior surface of the stone. It may increase the risk of migration of stone fragments into the upper calyx and removal of these fragments may be difficult after destruction. But middle calyx allows access to the main or superior surface of the stone. Therefore, the migration risk of fragments into the upper calyx is low.

Table 2. Operation-related parameters in middle calyx and lower calyx accesses

Parameter	Middle calyx access	Lower calyx access	*p* value
Anesthesia type: General/spinal, n (%)	48 (100%) / 0	118 (96.7%)/4 (3.3%)	0.58
Imaging for access: Fluoroscopy/ultrasonography, n (%)	42 (87.5%)/8 (12.5%)	101 (82.8%)/21 (17.2%)	0.45
Tubeless approach, %	89.6%	90.1%	1.00
Mean operative time (SE; range), minutes	60.7±40.9 (5.97; 15-240)	80.1±43.8 (3.98; 15-210)	0.002
Mean postoperative hospital stay (SE; range), day	1.84±0.82 (0.12; 1-4)	2.19±0.65 (0.06; 1-4)	0.005
Stone-free rate, %	89.6%	76.2%	0.054
Mean postoperative hemoglobin (SE; range), g/dl	13.00±1.55 (0.22, 9.1-15.5)	11.92±1.72 (0.15, 8.5-16.0)	<0.001
Mean hemoglobin drop (SE; range), g/dL	0.67±0.91 (0.13; 0-3.2)	1.36±1.31 (0.12; 0-7.5)	<0.001
Complication rate, %	10.4%	14.8%	0.46
Fever, n (%)	3 (6.2%)	7 (5.7%)	1.00
Transfusion, n (%)	1 (2.1%)	9 (7.4%)	0.28
Modified Clavien classification of complications			
Grade 0, % (no complication)	89.6%	85.2%	
Grade I, % (fever, self-limited gross hematuria treated by conservative management)	8.3%	5.7%	0.40
Grade II, % (transfusion)	2.1%	6.6%	
Grade III, % (gross hematuria, clot retention and ureteral obstruction requiring double-J stent)	0	2.5%	

SE: Standard error of the mean.

In our experience, middle calyx access (0.67 g/dL) had an acceptable mean hemoglobin drop compared to lower calyx access (1.36 g/dL). Aron and colleagues report an upper calyx access of 6 g/L and a lower calyx access of 6.5 g/L.[12] Shalaby and colleagues report mean hemoglobin drops of 0.52 g/dL for branched stones and 0.44 g/dL for multiple stones with lower calyx access.[21] In our study, the mean hospital stay for middle and lower calyx access was 1.84 days and 2.19 days, respectively. Nishizawa and colleagues report 20.6 days for mean hospital stay with lower calyx access.[11] Netto and colleagues report upper pole access at 3 days and middle/lower calyx access at 3.5 days);[14] Wong and colleagues[15] report a mean hospital stay of 2 days with the upper calyx access/total access ratio of 35/45 and Shalaby and colleagues[21] report a mean hospital stay of 3.92 days with lower calyx access. This matter may be due to shorter operative time and lower trauma in middle calyx access. Prolonged operative time significantly increases hemoglobin drop and blood loss.[23-25] In lower calyx access, the manipulation of the nephroscope and angle origination between the shaft of the nephroscope and dilation system or between working sheath and pelvicaliceal system may cause trauma and bleeding.[12] This trauma may lead to complications, which affects hospital stay.[26]

In our study, middle calyx access had acceptable complication rates (10.4%, ≥Grade III Clavien: 0%) compared to lower calyx access (14.8%). Aron and colleagues report rates of 12% and 15% for upper and lower calyx access, respectively;[12] Li and colleagues report major complications at 0.86%;[13] Netto and colleagues at 25% and 21.4% in upper pole and middle/lower calyx access, respectively;[14] finally Shalaby and colleagues report rates of 34.6%.[21] reports. Also, in middle calyx access (2.1%), the transfusion rate was lesser than in the lower calyx access (7.4%). Nishizawa and colleagues report 4.4%;[11] Netto and colleagues report 12.5% and 14.3% in upper pole access and middle/lower calyx access, respectively;[14] and Wong and colleagues report 2.2%.[15] Further complications were reported in other studies.[11,12,14,15,21] Our only important complication was gross hematuria (middle calyx access: 2.1%; lower calyx access: 3.3%) and clot retention and ureteral obstruction (lower calyx access: 2.46%). Due to potential intra-thoracic complications with the supracostal approach,[17,18] we used subcostal access in all PCNLs and our patients had no intra-thoracic complications. We had acceptable results with the middle calyx access.

There are limited published studies about middle calyx access PCNL, especially in the supine position.[11-18,21] Our research has its limitations: it was non-randomized, excluded single calyx stones, the groups had unequal patient numbers, stone location and surgeon decision were involved in the selection of calyx for access, only pneumatic lithotripter was applied and a stone-free result was not determined by CT scan. However, we were able to demonstrate that middle calyx access, compared to lower calyx access, can be easily used in the complete supine PCNL with good outcomes for pelvic, staghorn and multiple location stones. We believe that according to stone location and surgeon strategy, puncture of any calyx is the best access. It is safe and effective for reaching and removing stones.

Conclusion

Middle calyx access had superior outcomes, including shorter operative time and hospitalization, lower blood loss, better stone-free rate and acceptable complication rates. The middle calyx can be an optimal access in PCNL with the complete supine position for many of upper urinary tract stones.

Competing interests: None declared.

This paper has been peer-reviewed.

Acknowledgements: Urology Research Center, Razi Hospital, Guilan University of Medical Sciences, Rasht, I.R. Iran

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