ORIGINAL RESEARCH

Comparative Analysis of the Efficacy and Safety Profile of Upper Calyceal versus Lower Calyceal Access in the Percutaneous Nephrolithotomy (PCNL): A Retrospective Cross-sectional Study

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Introduction: The goal of PCNL is to achieve a high stone-free rate while minimizing complications. Its success results from an interplay of patient, stone and renal anatomical characteristics, the access site, and the level of surgical expertise. Data comparing upper versus lower calyceal PCNL as regards to efficacy and safety are limited.
Objective: To compare the clinical efficacy and safety outcomes of upper versus lower calyceal access in patients who undewent PCNL at St. Luke's Medical Center.
Methods: A retrospective chart review was done on patients who underwent PCNL at SLMC from January 2010-January 2015. The patients were classified based on the renal access site: Group 1 (upper calyceal) and Group 2 (lower calyceal). The stones were classified according to Guy Stone score and complications were summarized using the modified Clavien classification.
Results: A total of 91 patients underwent PCNL during the study period. Of these, only 84 patients were analyzed. Seven were excluded due to lack or incomplete postoperative imaging on follow up. Forty-one were included in Group 1, while 43 were included in Group 2. According to the Guy Stone score, the stones in Group 1 were 21(IV), 6(III), 7(II) and 6(1) while in Group 2, 18(IV), 5(III), 8(II), 12(I) (p-value=0.52) with a mean stone volume of 38.2±44.24cm^3 and 28.0±31.04cm^3 in Groups 1 and 2 respectively (p-value=0.23). Success rate was 80.5% and 83.7% for Groups 1 and 2 (p-value=0.70), respectively and mean stone clearance rates of 98.5% and 95.8% (p-value=0.13), respectively. The mean operative time was 181.0±82.26 and 169.5±52.12mins for Groups 1 and 2 (p-value=0.451), respectively. A total of 36 complications (13 from Group 1 and 23 from Group 2) were evaluated. Fever (Grade 1) occurred in 10 (24%) and 17 (39%) for Groups 1 and 2, respectively. Blood transfusion (Grade 2) was observed in 4(9%) patients and 3(7%) in Groups 1 and 2, respectively. Two patients (5%) in Group 2 required postoperative double-J stent insertion due to ureteral stone migration (Grade 3). There was no significant difference noted among the groups as regards complication rates (p-value=0.097) and length of hospital stay (p-value=0.687). There was no mortality in either group.
Conclusion: Based on our experience, both upper and lower calyceal access PCNL achieve equivalent efficacy and comparable safety profile in the treatment of complex renal stones.

Key words: upper calyceal access percutaneous nephrolithotomy

Introduction

Percutaneous nephrolithotripsy (PCNL), introduced in 1970s has revolutionized the treatment for renal stones[1], and is presently considered as the standard treatment of choice for large and complex renal stones as presented in the AUA and EAU Urolithiasis Guidelines 2015.

At present, several studies have been made and they emphasized their high stone-free and success rates exceeding 90%.[2] There have been continued efforts to maintain if not improve patient outcome and current success rates while decreasing complication and morbidity.[3] Hemorrhage, intrathoracic complications and other organ injuries are among the established complications reported in literature.[4]

The objective of the study was to compare the efficacy and safety profile of upper calyceal vs lower calyceal access in patients with complex renal stones (Guy's stone grade I-IV) who underwent PCNL from January 2010 to January 2015 at St. Luke's Medical Center.

Materials and Methods

This is a retrospective cross-sectional study that included adult patients (>18 years old), diagnosed with complex renal stones (Guy's stone grade I-IV) who underwent PCNL from January 2010- January 2015 at SLMC. Patients who underwent either upper calyceal or lower calyceal access for PCNL were included in the study and analysis. Patients were categorized according to location of renal access: Groups 1 and 2 for upper and lower pole accesses, respectively. Excluded in the study were pediatric patients (<18 years old), patients with congenital renal anomalies, patients with previous open or percutaneous renal surgeries, and patients who underwent PCNL with multi-tract access and non-comparable preoperative and postoperative imaging modality.

The mean stone volume, operative time, and length of hospital stay were compared between the two groups. Stone-free rates were calculated and compared among the two groups. In addition, the intraoperative and postoperative complications such as intraoperative bleeding, number of blood units transfused, intraoperative conversion to open surgery, postoperative fever, and other complications were also reported. The mean stone size, measured as the widest dimension in millimeter, and stone clearance, a measure in inverse percentage of the amount of renal stone left after PCNL, were assessed by comparing the pre-operative and postoperative diagnostic imaging modality. The mean operative time is the duration of the operation from initiation of the procedure until its termination. The mean length of hospital stay is the number of days the patient has been admitted from the first postoperative day to discharge. Intraoperative conversion to open surgery is considered as a complication. Included in the postoperative complications were post-operative bleeding, fever, other visceral and intrathoracic complications and death associated with the procedure. Particularly, intraoperative and postoperative bleeding or blood loss was measured by determining the mean change in hemoglobin and hematocrit as well as the total blood products transfused. Surgical risk stratification was assessed using American Society of Anesthesiologist scoring system, while post-operative complications were graded using Clavien-Dindo classification. Statistical analyses were done using SPSS Version 14 for Windows. The statistical inference was obtained by computing Z test, Mann-Whitney test, t-test for the difference between any two values and considered as statistically significant if the $P < 0.05$.

Confidentiality of all data was assured. The Institute of Urology case census was secured with unique password, only the institute medical staff personnel had access. Only the investigators of this study were given access to the study data.

Results

A total of 91 records of patients who underwent PCNL from January 2011 to January 2015 were reviewed but only 84 qualified for the study. Seven patients were excluded due to inadequacy of work-ups. Forty-one patients (Group 1) with mean stone volume of $38.2 \pm 44.24 cm^3$ were included in the upper calyx group, and 43 patients (Group 2) with mean stone volume of $28.0 \pm 31.04 cm^3$ were included in the lower calyx group (p-value=0.228). (Table 1) No significant differences were observed in between the groups' demography with regards to the age, gender, Guy stone scoring, preoperative hemoglobin and hematocrit levels. The success rate was 80.5% for upper calyceal access versus

83.7% for lower calyceal access with p-value=0.699 and mean stone clearance rates of 98.5% versus 95.8% (p-value=0.126), respectively. The mean operative time was 181.0±82.26mins for upper calyceal access versus 169.5±52.12 for lower calyceal access (p-value=0.451), respectively. (Table 2) Blood transfusion for bleeding occurred in 4 patients in the upper calyx group and 3 in the lower calyx group. Fever was observed in 10 patients from the upper calyx group, and 17 patients from the lower calyx group. Two patients from the lower calyx group underwent reoperation for double-J stent insertion. The mean length of hospital stay was 4.85±2.28 days versus 4.63±2.78 days for upper and lower calyceal access, respectively.

Discussion

The success of PCNL is a result of an interplay between the patient characteristics and

Table 1. Patient demographics

Characteristics	Access		P-value
	Upper Calyx (N= 41)	Lower Calyx (N=43)	
Age	48.5±10.26	50.3±10.67	0.449
Sex			
Male	20	21	0.996
Female	21	22	
Laterality			
Right	22	16	0.130
Left	19	27	
Guy Stone Score			
I	7	12	0.516
II	7	8	
III	6	5	
IV	21	18	
Stone Volume (cm^3)	38.2±44.24	28.0±31.04	0.228
Preoperative Hemoglobin (g/dL)	13.6±1.78	13.52±1.75	0.794
Preoperative Hematocrit (%)	40.7±5.19	40.7±4.43	0.992

Table 2. Perioperative outcomes

Outcomes	Access		P-value
	Upper Calyx (N= 41)	Lower Calyx (N=43)	
Operative Time (min)	181.0±82.26	169.5±52.12	0.451
Postoperative Hemoglobin (g/dL)	12.1±1.97	11.9±1.63	0.634
Hemoglobin drop (g/dL)	1.5±1.05	1.5±1.26	0.730
Postoperative Hematocrit (%)	36.8±5.85	35.9±5.05	0.493
Hematocrit drop (%)	3.9±3.13	4.7±3.84	0.294
BT required	9.8% (4)	7% (3)	0.473
Hospital Stay in days	4.85±2.28	4.63±2.78	0.687
Complications			
Fever	10	17	0.097
Reoperation	0	2	

Table 3. Surgical outcomes

Outcomes	Access		P-value
	Upper Calyx (N= 41)	Lower Calyx (N=43)	
Stone Clearance Rate	98.5±3.37	95.8±11.14	0.126
Overall Results			
Success Rate	80.5% (33)	83.7% (36)	0.699
Failure Rate	19.5% (8)	16.3% (7)	

Table 4. Success rate of PCNL accesses among subgroups

Guy Stone Score	Stone Free		P-value
	Upper Calyx (N= 33)	Lower Calyx (N=36)	
I	100% (7)	91.7% (11)	0.350
II	71.4% (5)	75% (6)	
III	50% (3)	100% (5)	
IV	85.7% (18)	77.8% (14)	

the surgical technique. Patient factors include the stone size, morphology and total stone burden, calyceal stone location and the complexity of renal anatomy. Surgical technique factors include the number of renal access (single or multi-tract PCNL), the intracorporeal energy sources utilized, and more importantly the surgeon's surgical experience and capability of establishing an effective upper, middle, or lower calyceal access of the renal calyx which is considered the critical initial step for PCNL.[5] This present study resulted to overall success rate of 80.5% for upper calyceal access and 83.7% for lower calyceal access (p=0.699). The authors felt that this may be due to the more complex stone characteristics noted in the upper calyceal access group compared to the lower calyceal access group. Twenty-five patients had less complex Guy stone score I-III in the lower calyceal access group versus 18 patients in the upper calyceal access group. The more complex Guy stone score IV was observed in 21 versus 18 patients who underwent upper and lower calyceal access, respectively. Further subgroup analysis revealed a higher success rate (85.7%) for upper calyceal access when compared to lower calyceal access (77.8%) when dealing with complex stones (Guy stone score IV). However, while some reviews have considered upper calyceal renal access for complex renal stones to be effective when used with caution[6], a large scale analysis from the CROES Percutaneous Nephrolithotomy Global Study has established a high complication rate and lower stone-free rate due to complexity of the procedure.[7] In the present study, the main complication seen in both groups was fever in 27 patients and reoperation (J-stent insertion) in 2 patients. More patients developed fever in the lower calyceal access group versus 10 in upper calyceal access group. None of them, however progressed to sepsis. In a study by Olbert, et al.[8], no direct relationship or occurrence pattern was established among patients who underwent PCNL and development of fever, UTI, and even sepsis. Two patients under the lower calyceal group access underwent double J-stent insertion due to severe flank pain and hydronephrosis of the ipsilateral kidney following the procedure. With a 3-16% range of developing intrathoracic complications[9], none of the patients developed thoracic complication in the present study, especially in the upper calyceal access group. A total of 3 versus 4 patients underwent blood transfusion for lower and upper calyceal access, respectively. No significant difference was however observed in the postoperative drop in hemoglobin (1.5±1.05 vs 1.5±1.26, p= 0.730), and hematocrit (3.9±3.13 vs 4.7±3.84, p= 0.294) of upper versus lower calyceal access, respectively. Similar results were observed in the study of Verma, et al.[10] On the contrary, in a study by Arom, et al. although used more often because of lower complication rate, difficulty in obtaining an acceptable stone free rate has been associated with an inferior calyceal renal access.[11] With the evidences at hand, existing data have been inconclusive of the best renal access for PCNL. Ideally, the choice of renal access should allow the surgeon to freely mobilize the rigid instrument inside the kidney to achieve acceptable stone-free rate while minimizing the risk of complications.[5] With the use of flexible nephroscopes, a single upper pole puncture may be enough and may even obviate the need for multi-tract punctures. It is believed that the upper calyceal access allows more favorable manipulations of the instrument within the pelvocalyceal complex when compared to lower calyceal access due to the differences in their anatomical angulation and torque. The upper calyceal system provides a better visualization of the pelvocalyceal complex due to a straight tract from the upper infundibulum and the more posterior orientation of the the upper calyceal system when compared to the lower calyceal system.[4] Being a highly technical endourological procedure, its success is influenced by both the surgeon's surgical skills and the availability of image-guided technology. For instance, the ease of access is partly dependent on the use of radiologic imaging to include the use of fluoroscopy and/or ultrasound.[12] In a study of 8,025 cases of PCNL in China, the complication and safety of which showed that X-ray free Doppler ultrasound guided PCNL has been safe and effective.[13] Overall, however, the use of fluoroscopy remains to be the most commonly used modality.[14] The type of energy source for intracorporeal lithotripter also allows better stone-free rate when dealing with complex renal stones.

The ultrasonic and pneumatic lithotripter is among the basic energy sources used for PCNL. The efficiency of these two energy sources however is increased when used in combination.[15]

Conclusion

Upper and lower calyceal accesses for PCNL achieve equivalent efficacy in stone-free rates and safety in terms of perioperative parameters, surgical complications, and the length of hospital stay. The key factors to a successful PCNL procedure are: an appropriately chosen access site, atraumatic entry into the collecting system, and a meticulous and careful handling of the nephroscope and intracorporeal devices for disintegration and stone retrieval.

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