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Calyceal Access in Supine Percutaneous Nephrolithotomy for a Renal Pelvis Stone: Efficacy and Safety

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Abstract

Background: Supine PCNL offers great benefit from urological and anaesthetic point of view. So far no study has ever been done in Malaysia to evaluate the outcomes of different access route in supine PCNL. We aim to compare the safety and efficacy between single upper, middle and lower calyceal access in patients with a single renal pelvis stone with or without calyceal extension.

Methods: A 73 renal pelvis stones (2 to 3 cm) who had a single renal access during supine percutaneous nephrolithotomy between November 2020 to August 2022 were retrospectively reviewed. Stone free rate, complication rate and blood transfusion rate were compared between three groups of calyceal accesses using Chi-square or Fisher's Exact test as appropriate.

Results: There were 17, 29 and 27 renal pelvis stones in the upper, middle and lower calyceal access group respectively. Median follow-up was 14.1 months at the date of writing. There was no statistically difference in terms of age, gender, American Association of Anaesthesiologist class, body mass index, stone burden and Hounsfield Unit between two groups. Although not statistically different, middle calyceal access group has higher stone free rate and shorter operative time. There was, however, one transfusion required in the middle calyceal access group ($p = 0.463$).

Conclusion: Single middle calyceal access for supine percutaneous nephrolithotomy for a renal pelvis stone is safe and effective.

Keywords: Supine PCNL; Renal stone; Urolithiasis; Endourology

Introduction

Percutaneous nephrolithotomy (PCNL) is strongly recommended for the treatment of large, multiple and complex renal stones [1,2]. It had the highest single-treatment stone-free rate (SFR) when compared with other treatment modalities for renal stones such as extracorporeal shockwaves lithotripsy (ESWL) [3]. And retrograde intrarenal surgery (RIRS) [4]. The main concern of PCNL is the higher rates and severity of complication than other treatment options [5]. Percutaneous renal access is the most important step in PCNL because it is the only way to reach and manage the stones. This access can be through the upper, middle or lower calyx. Upper calyceal access is preferred for the treatment of complex and staghorn stones [7,8]. However, many urologists prefer lower calyx access because of the lower risk of pleural injury [6]. Middle calyceal access (MCA) is often underutilized in standard PCNL [9]. From urologist point of view, supine PCNL offers better ergonomics for surgeon, shorter operative time due to easier patient positioning, reduced intrarenal pressure leading reduced risk of urosepsis and room for endoscopic combined intrarenal surgery (ECIRS) or simultaneous bilateral endoscopic surgery (SBES). Not only that, supine PCNL certainly offers great advantages over prone PCNL in terms of anesthesiologist management. This includes improved access to the patient for cardiovascular and pulmonary management (especially during an emergency situation), less risk of injury to central and peripheral nervous system, less risk of thromboembolism due to the lack of inferior vena cava compression [10]. And improved ventilator-associated parameters for obese patients [11]. Moreover, there is no need for extra anaesthesiologic equipment such as reinforced endotracheal tubes, stabilizing helmet, specialized paddings which may add additional cost to the procedure. This study was conducted to compare efficacy and safety between a single upper, middle and lower calyceal access in s-PCNL for a renal pelvis stone.

Patients and Methods

Patients selection

This was a retrospective cohort study. Subjects were sampled via convenient sampling method. We have treated 100 renal or ureteric stones using s-PCNL in Sarawak Heart Institute from November 2021 to August 2022. A 4 patients were excluded due to incomplete data collection. Renal units with renal pelvic stone (with or without calyceal extension) AND maximum stone diameter ranging 2 to 3cm AND treated with single renal access were included in the study. Staghorn calculi, pre-existing nephrostomy tube, ureteric stones and radiolucent stones were excluded.

Methodology

Computed tomography (CT) was used for preoperative evaluation of stone burden, pelvicalyceal system anatomy and retrorenal colon. Laboratory tests included urine analysis and culture, serum creatinine, FBC, CRP and INR. Patients with coagulopathy or receiving anticoagulants did not undergo s-PCNL. Culture-specific antibiotics were administered for patients with infected urine culture, and then s-PCNL was performed when the culture became not infected. All patients were well consented before operation. This operation was performed by a single urologist in the centre. After administration of prophylactic antibiotic (Cefoperazone 1g i.v.) and under general anaesthesia, the patient was placed in modified Giusti position and posterior axillary line was marked as the anterior limit of skin puncture during PCNL. Patient was then cleaned and draped, followed by placement of ureteric catheter at the renal pelvis under fluoroscopic guidance. Then a retrograde renal pyelogram (RPG) was performed to delineate the pelvicalyceal system to decide on the most suitable calyx for percutaneous renal access. For example, a focal caliectasis is preferred over a non-caliectasis calyx. Most of the time, middle calyceal access is doable as it has the easiest axis puncture unless there are no middle calyx in the renal units. Percutaneous renal access was done either under bi-plane C-Arm fluoroscopic guidance, USG-guidance, or both methods to the most suitable calyx for complete clearance of the renal stones. After passing a 0.035 inch Roadrunner guidewire into the pelvicalyceal system or ureter, the tract was dilated using sequential dilators (Amplatz) to the size of 24Fr sheath. A standard rigid nephroscope of 22Fr was used for a 24Fr tract. Continuous irrigation system was connected to the nephroscope whereby the irrigation saline was at height 60cm above the patient's centre point. Stones were disintegrated with ultrasonic lithotripters. Big fragments were evacuated through the sheath; by application of vacuum cleaner effect, or by forceps. The collecting system was inspected by the rigid nephroscope and/or 16Fr-flexible cystoscope for residual stones. In addition, fluoroscopy was used to ensure complete clearance of all stone fragments. At the end of the procedure, a 18Fr nephrostomy tube was inserted with or without ureteric stent under fluoroscopic guidance. A Foley urethral catheter was then inserted. A plain film of the kidney, ureter and bladder (KUBXR) was performed in the first postoperative day for the confirmation of the proper stent position (if any). Another KUBXR will be performed 30 days later for evaluation of stone free status. If there were no complications and urine was clear, the urethral catheter, ureteric catheter and nephrostomy were removed, and the patient was discharged. The stent (if any) was removed at 2 weeks postoperatively under local anaesthesia.

Measures

Demographic and post-operative outcome were recorded. Post-operative outcomes included operative time, length of hospital stays (LOS), and stone free rate, major complication rate and transfusion rate. The stone clearance status was assessed by Kidney-Ureter-Bladder X-ray at 1 month post-operative and stone Free State refers to a patient who may still have residual stone of maximum diameter less than 4mm [18]. Major complication in our study is defined by Clavien-Dindo class 3 and above.

Statistical analysis

Cases were divided into three cohorts; single upper calyceal access (UCA), single middle calyceal access and single lower calyceal access (LCA) respectively. Mean and standard deviation (SD) or median and interquartile range (IQR) were used for the descriptions of quantitative variables, and frequency and percentage were used for qualitative variables. Continuous variables were compared using the one-way ANOVA test, whereas categorical variables were compared using the Chi-square or Fisher's Exact test as appropriate. A p-value <0.05 was considered statistically significant. Statistical analyses were conducted in IBM SPSS, version 25, Macintosh OS.

Ethics and Consent

Institutional review board approval was obtained from National Medical Research Register (NMRR ID-21002225-WLP). Informed consent was obtained from all individual participants included in the study. All the participants were consented to the submission of the data to the journal.

Results

A 73 cases were included in this study. There were 17, 29 and 27 cases in single UCA, MCA and LCA respectively. Patient demographic data are presented in Table 1. There were no statistically significant differences among the patient groups with respect to age, gender, ASA class, BMI, stone laterality and maximum stone diameter. Most of the patients (at least 95%) were in ASA class 1 to 2 and about one-third of patients were obese in all study groups. Median follow-up was 14.1 months at the date of writing (IQR 8.5 to 18.8 months). Operative details and postoperative outcomes are summarized in Table 2.

***Table 1**: Patient and stone characteristics.*

Characteristics	UCA (n = 17)	MCA (n = 29)	LCA (n = 27)	p-value
Age, year, mean (SD)	49.2 (16.2)	45.7 (10.7)	50.9 (12.1)	0.306
Gender, n (%)				0.71
Male	9 (52.9)	18 (62.1)	14 (51.9)	
Female	8 (47.1)	11 (37.9)	13 (48.1)	
ASA class, n (%)				0.731
1 – 2	17 (100.0)	28 (96.6)	26 (96.3)	
3 – 4	0 (0.0)	1 (3.4)	1 (3.7)	
BMI, kg/m^2, n (%)				0.609
< 30	11 (64.7)	20 (69.0)	21 (77.8)	
≥ 30	6 (35.3)	9 (31.0)	6 (22.2)	
Stone laterality, n (%)				0.158
Right	7 (41.2)	20 (69.0)	14 (51.9)	
Left	10 (58.8)	9 (31.0)	13 (48.1)	
Maximum stone diameter, cm, mean (SD)	2.6 (0.9)	2.9 (1.3)	2.7 (1.1)	0.564
HU, mean (SD)	1230.2 (317.3)	1112.5 (236.3)	1181.4 (252.4)	0.332

UCA, upper calyceal renal access; MCA, middle calyceal renal access; LCA, lower calyceal renal access; ASA, American Society of Anaesthesiologists; BMI, body mass index; HU, Hounsfield unit.

MCA group (80.2 minutes) has comparable operative time as compared to UCA (78.9 minutes) but relatively shorter as compared to LCA group (91.8 minutes) (p = 0.233). Tract size of renal access and LOS were comparable in both groups. Although no statistically significant different, stone free rate was higher in MCA group as compared to UCA/LCA group (86.2% vs 70.6%/81.5%, p = 0.428). Major complication rate were 1/1/2 case(s) in UCA/MCA/LCA groups (p = 0.835). In UCA group, there was one patient required secondary PCNL due to profuse parenchymal bleed causing poor endoscopic vision and hence abandonment of primary PCNL (Clavien 3B). In MCA group, there was one patient required selective renal angioembolization due to pseudoaneurysm (Clavien 3A). In LCA group, there was one patient required ICU admission for abdominal compartment syndrome post-PCNL due to irrigant extravasation (Clavien 4A) and one patient with obstructed migrated stent in a solitary kidney which required stent change (Clavien 3A). One blood transfusion event was recorded in the MCA group. There were no event of pleural injury, colonic injury, splenic injury and death observed in our study.

Discussion

We are presenting from a urology department in district hospital in Malaysia. There are only a few anaesthesiologists here that are comfortable ventilating patient in prone position. Because of that, Urology department of Sarawak Heart Centre is the one of the few centres that perform supine-only PCNL on a regular basis. Undoubtfully, renal access in PCNL plays an important role in the success of surgery. Traditionally, the upper and lower renal calyceal accesses are the most preferred one because theoretically it follows the natural longitudinal axis of a kidney and assumed that stone can be cleared in single access. However, unlike in prone PCNL, upper pole calyx of a kidney in modified Giusti position is not readily accessible as the kidney is surrounded by liver (right side) and spleen or pleural (left side).

Table 2: *Operative details and postoperative outcomes.*

Parameters	UCA (n = 17)	MCA (n = 29)	LCA (n = 27)	p-value
Operative time, minute, mean (SD)	78.9 (28.4)	80.2 (28.3)	91.8 (30.1)	0.233
LOS, day, mean (SD)	2.2 (1.4)	2.2 (1.1)	2.0 (1.3)	0.838
Major complication, n (%)				0.835
Yes	1 (5.9)	1 (3.4)	2 (7.4)	
No	16 (94.1)	28 (96.6)	25 (92.6)	
Transfusion needed, n (%)				0.463
Yes	0 (0.0)	1 (3.4)	0 (0.0)	
No	17 (100.0)	28 (96.6)	27 (100.0)	
Stone free, n (%)				0.428
Yes	12 (70.6)	25 (86.2)	22 (81.5)	
No	5 (29.4)	4 (13.8)	5 (18.5)	

UCA, upper calyceal renal access; MCA, middle calyceal renal access; LCA, lower calyceal renal access; LOS, length of hospital stays.

Therefore, to access the upper pole in s-PCNL, a skillful urologist is required to tilt the kidney inferiorly using the Chiba needle under fluoroscopic guidance before puncture. Although there are no vital solid organ at the vicinity of puncture in lower pole of a kidney, access to the lower pole renal calyx is can be difficult especially during tract dilatation due to its high mobility and almost always ended with a long tract. On the other hand, in our opinion, middle calyx renal access in s-PCNL is easy as it is always subcostal and it has shorter a skin-calyceal distance when compared to upper or lower renal calyceal access. Furthermore, it is easy to identify the posterior middle calyx when obtaining a renal access using ultrasound guidance compared with fluoroscopic guidance. From our early experience in s-PCNL, we also realized that manoeuvring nephroscope is always limited by costal margin (in upper pole access) and iliac crest (in lower pole access), thus limiting the access to minor calyx with extreme angle. Moving a nephroscope via a lower calyceal access become more difficult when a long tract is created. In our study, the operative time was shorter in the upper/middle calyceal access group when compared with lower calyceal access group (78.9/80.2 vs 91.8 minutes, $p = 0.233$), which has already been proved in a few non-local studies. A study by Yan Song et al, the mean operative time was 46 / 41.2 / 50.2 minutes in upper / middle / lower calyceal access group ($p < 0.001$) [12]. Nishizawa [13]. And Li [14]. Also reported that the mean operative time was 129.5 and 78 minutes with lower and middle calyceal access respectively. Although not statistically different, a prone mini-PCNL study by Sanjay Khadgi also showed that the operative time for single middle calyceal access is shorter than upper/lower calyceal access (45.2 vs 48.7 minutes, $p = 0.051$) [15]. With better nephroscope mobility within the pelvicalyceal system, it is not surprised that a higher stone free rate was observed in the single middle calyceal access group in comparison with single upper/lower calyceal access (86.2% vs 70.6/81.5%, $p = 0.428$). Yan Song et al compared the stone free rate between different calyx access group and reported that single middle calyceal access achieved significantly higher stone free rate than single upper/lower calyceal access (98.2% vs 93.3/84.3%, $p = 0.037$). A study by Falahatkar et al, which excluded upper pole renal stones and upper pole calyceal access renal units, showed that the stone free rate of single middle calyceal access was higher than that of single lower calyceal access (89.6% vs 76.2%, $p = 0.054$) [16]. The higher stone free rate may result from the easy access via the middle calyx, proper angle between the middle calyx tract and long axis of the kidney, optimal alignment of this access with the ureteropelvic junction, and easy access to the renal pelvis and upper ureter for stone removal. In our experience, the major complication was not statistically different between single middle calyceal access group and single upper/lower calyceal access group (3.4% vs 5.9% / 7.4%, $p = 0.835$). Yan Song et al demonstrated no statistical difference in complication rate between upper/middle/lower calyceal access group (17.8%/14%/15.7%, p = 0.862). Falahatkar et al pointed out that middle calyceal access had acceptable complication rate (10.4%) when compared to lower calyceal access (14.8%) (p = 0.4) [16]. Although Boon et al [17]. Found that the risk of injuring the colon increased when puncturing the lower pole of kidneys, based on our experience, it is relatively unchallenging to identify the posterior calyx under ultrasound and avoid organ injuries. The complication rate of our study was comparable with other non-local series.

Study Limitations

Nonetheless, this study has some limitations. First of all, all the cases are done by a single urologist and such result may not be reproducible by other urologist. Second, this is a retrospective analysis and collection of data may be incomplete especially if the patients comes from far away locations in Sarawak (e.g. Lawas, Limbang, Kapit, Belaga). Second, the number of subjects was small because supine PCNL is not as popular as prone PCNL in Malaysia. Third, evaluation of "stone-free" status post-operatively might be inadequate with KUBXR due to resources limitation in a district hospital. Having to say that, all of the selected renal units for this study are radiopaque.

Conclusion

In conclusion, supine PCNL is safe and effective in single renal pelvic stone with or without calyceal extension. Supine PCNL also offers many extra benefit such as surgeon ergonomic and easier airway management. Although statistically insignificant, single middle calyceal access had better outcomes in terms of operative time and stone-free rate when compared to a single upper or lower calyceal renal access in our study.

List of Abbreviations

PCNL: Percutaneous Nephrolithotomy; s-PCNL: Supine Percutaneous Nephrolithotomy; ESWL: Extracorporeal Shockwave Lithotripsy; RIRS: Retrograde Intrarenal Surgery; Ho:YAG: Holmium: Yttrium, Aluminium, Garnet; SFR: Stone Free Rate; UCA: Upper Calyceal Access; MCA: Middle Calyceal Access; LCA: Lower Calyceal Access; KUBXR: X-Ray Of Kidney, Ureter And Bladder; USG: Ultrasound; NCCT: Non-Contrast Computed Tomography; RPG: Retrograde Pyelogram; BMI: Body Mass Index; ROC: Receiver Operating Characteristic; AUC: Area Under Curve; FBC: Full Blood Count; INR: International Normalized Ratio

Conflict of interest statement

The authors declare no conflict of interest.

Financial disclosure statement

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