The Best Calyceal Tract Approach for Treating Renal Stones with Percutaneous Nephrolithotomy

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Objective: *To compare the perioperative outcomes of percutaneous nephrolithotomy (PCNL) performed via the upper, middle, and lower calyces.*

Material and Method: *The authors retrospectively reviewed 92 renal units in 92 patients who required PCNL at our institution between 2006 and 2010. Patients with partial and full staghorn stones with total stone size ≥2 cm were included in the present study. Patients were excluded if they had multiple small stones or a single stone <2 cm. The present study analyzed 92 renal units in 92 patients. The authors divided the patients into three groups (groups 1, 2, and 3) based on the surgical approach, which was the upper, middle, and lower calyceal approaches. PCNL was performed using a standard ultrasonic lithotriptor with a rigid nephroscope, and holmium: YAG laser lithotripsy was carried out with a flexible nephroscope, with simultaneous nitinol tipless basket extraction of fragments. Procedures were repeated until the patients were rendered stone-free (confirmed visually or by nephrostogram). Estimated blood loss, length of hospital stay, operative time, and the number of procedures (to achieve stone-free status) were analyzed and compared among the groups, and complications were reported.*

Results: *The present study showed that the length of hospital stay, estimated blood loss, number of procedures, and operative time were not significantly different between the three groups. In Group 1, four patients had complications and included two patients with mid-ureteral stone, and one patient each with renal pelvic perforation and urinary tract infection with sepsis. One patient from Group 2 contracted a urinary tract infection. In Group 3, five patients exhibited complications and included one with mid-ureteral stone, two with renal hemorrhage, and two with urinary tract infection.*

Conclusion: *The estimated blood loss, duration of hospital stay, operative time, number of procedures (to achieve stone-free status), and complications did not statistically differ between the three groups. Moreover, very few complications occurred in the different surgical approaches. Therefore, PCNL via all the three approaches were deemed safe and effective.*

Keywords: *Percutaneous nephrolithotomy, Upper calyx, Middle calyx, Lower calyx access*

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The management of kidney stones has undergone tremendous changes over the last 10 to 15 years. Prior to these modifications, kidney stones were all managed by open pyelolithotomy or nephrolithotomy, which resulted in significant morbidity for the majority of the patients. Percutaneous access was initiated in 1955 when Goodwin and his associates performed the first percutaneous nephrostomy via a tract for drainage of pus and urine. In the late 1970s, the tract was used for kidney stone removal. It was initially carried out at specialized centers and used only to treat high-risk patients, but over time it is practiced across multiple centers and has replaced open operation in the majority of patients with renal stones and has now become the standardized technique for the removal of large renal stones (>2 cm)[1-3].

Urologists are constantly challenged to select the position of calyx that is appropriate to obtain the most safe and successful outcomes. While many studies have reported complete kidney stone removal via the upper calyceal approach, pneumothorax is a severe complication encountered in this approach. On the other hand, while there are fewer complications in the lower calyceal approach, the efficacy of stone removal is low[4,5].

Therefore, the authors aimed to compare the outcomes of percutaneous nephrolithotomy (PCNL) carried out via the upper, middle, and lower calyx approaches.

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Material and Method

The authors retrospectively reviewed 92 renal units in 92 patients who underwent PCNL at Ramathibodi Hospital between 2006 and 2010. The inclusion criteria were partial and full staghorn stones with a total stone size ≥2 cm. Patients with multiple small stones or a single stone with total size <2 cm were excluded from the analysis. The authors divided the patients into three groups according to the surgical approach, the upper calyceal approach (Group 1), the middle calyceal approach (Group 2), and the lower calyceal approach (Group 3). The stone burden was defined as the two-dimensional areas obtained by measuring the length and width of the stone on preoperative plain abdominal radiograph. PCNL was performed by three urologists while the subjects were under general anesthesia. Prophylactic antibiotics were administered to prevent bacteremia[6]. Percutaneous renal access was performed by urologists or radiologists[7]. The patient lay in the supine position, and fluoroscopic guidance was used to identify the appropriate calyx after injection of contrast medium via the ureteric catheter. Then, an 18-guage needle was used to puncture the calyx and a floppy-tipped guidewire was inserted through the needle into the collecting system and passed down into the ureter. An approximately 1-cm-long skin incision was made, following which the nephrostomy tract was dilated using fascial dilators and the fluoroscopic guidewire was advanced to the collecting system. An Amplatz sheath 30 was deployed over the metal dilator, which was deflated and removed while the guidewire was still in place. The nephroscope was then inserted along the sheath to identify the stones, which were then fragmented into small pieces by an ultrasonic lithotriptor. Finally, a silastic tube was placed as the nephrostomy tube, and its position was confirmed using a contrast media study[8-10]. All stone clearance was assessed by a plain KUB on first postoperative day, and the operation was repeated in case the residual stone was >10% of the stone burden. In patients with complete clearance, the nephrostomy tube was removed when the hematuria had resolved. A routine nephrostogram was obtained in all patients. Successful stone removal was defined as complete clearance of the stone, and insignificant residue was defined when there were residual fragments <2 mm in size.

The estimated blood loss (cc), hospital stay (days), operation time (minutes), number of procedures (to achieve stone-free status), and complications were analyzed and compared among the three groups.

Statistical analysis

Quantitative data were reported as the mean. The Kruskal Wallis test and Fisher's exact test were used to compare the quantitative and qualitative data among the groups, respectively. A value of $p<0.05$ was considered statistically significant.

Statistical analysis was performed using SPSS® version 16.

Results

Ninety-two renal units from 52 men and 40 women were included in the present study. The patients were divided into three groups depending on the type of surgical approach, upper (Group 1, n = 45), middle (Group 2, n = 9), and lower (Group 3, n = 38) calyceal access (Table 1).

The mean hospital stay (days) in groups 1, 2, and 3 was 7.91, 7, and 6.42 days, respectively. The estimated blood loss (cc) in the three groups was 190, 96.67, and 198 cc, respectively. The operative time (minutes) of the three groups was 107, 85.56, and 87.24 minutes, respectively. The number of procedures (number of times) in each group were in Group 1, one time (62.2%) and two times (37.8%), in Group 2, one time (88.9%) and two times (11.1%), and in Group 3, one time (81.6%) and two times (18.4%). Values were considered significant at $p<0.05$ (Table 2).

Four patients in the upper calyceal access group experienced complications, two patients had

Table 1. Renal stone distribution and number of stone (n = 92)

Stone distribution	Upper calyx access	Middle calyx access	Lower calyx access
Lower calyx and pelvis	8	-	10
Lower calyx	-	-	12
Pelvis	5	2	6
Upper, middle, lower and pelvis	5	-	2
Middle, lower and pelvis	4	2	2
Upper calyx and pelvis	7	-	-
Upper, lower calyx	5	-	1
Middle, lower calyx	2	2	1
Upper calyx	5	-	-
Upper, middle, lower calyx	2	-	1
Middle and pelvis	-	3	2
Upper, middle, calyx	2	-	1
Total	45	9	38

Table 2. Clinical outcomes (n = 92)

Outcome	Upper calyx access (n = 45)	Middle calyx access (n = 9)	Lower calyx access (n = 38)	p-value
Estimated blood loss (ml)	190	96	198	0.47
Length of hospital stay (day)	7.91	7.00	6.42	0.28
Number of procedure for stone render free	1 time/62.2% 2 time/37.8%	1 time/88.9% 2 time/11.1%	1 time/81.6% 2 time/18.4%	0.33 0.23
Operative time (min)	107.00	85.56	87.24	0.38

Table 3. Complication

Complication	Upper calyx access	Middle calyx access	Lower calyx access
Mid ureteric stone	2	-	1
Renal pelvic perforation	1	-	-
Urinary tract infection with sepsis	1	-	-
Urinary tract infection	-	1	2
Renal hemorrhage	-	-	2
Total	4	1	5

mid-ureteral stone. Further, one patient in group 1 had renal pelvic perforation and one had urinary tract infection with sepsis. In Group 2, one patient contracted a urinary tract infection. Finally, in Group 3, five patients had complications that were mid-ureteral stones (1), renal hemorrhage (2), and urinary tract infections (2) (Table 3).

Discussion

The success of staghorn treatment still poses a challenge for urologists. Due to the size of the stone and the anatomy of the kidney, most stones are struvite stones, and it is difficult to remove the entire stone in a single intervention. Further, in this type of stone, there is high frequency of recurrence of stone formation. The recurrence rate of stone formation after the open stone surgery for struvite stones is 30% over a 6-year follow-up[11]. Since these stones are infectious, bacteremia may occur during the intervention. Therefore, total removal of the stone and antibiotic prophylaxis is required in all cases. In case of residual stones or small stone fragments after surgery, stone regrowth has been reported in approximately 75% of patients after extracorporeal shock wave lithotripsy (ESWL), as compared with 10% in patients in whom complete stone removal was achieved[12,13]. The residual stones are particularly harmful because they provide a habitat for the bacteria, causing constant postoperative bacteriuria and result in persistent infection.

When the staghorn stone size is >2 cm, puncture should be considered. This results in reduced injury of kidney parenchyma as compared to nephrolithotomy, and it is associated with decreased risk of blood loss from large open surgical wounds and renal parenchyma. The risk of hemorrhage requiring transfusion in PCNL is 3 to 28%[14]. The multiple punctures and the renal pelvic perforation were the only factors that cause blood loss during PCNL. The optimal site of puncture depends on the position of the stone and the urologist's experience. In staghorn stones over 2 cm in size, the upper pole access is favored because lower and middle poles of the kidney are anteriorly tilted along the psoas muscle, and the superior access is preferred as the tract to the lower calyx, pelvis, ureteropelvic junction (UPJ), and the upper ureter is straight, making it feasible to attack the stones[4]. In some patients, however, the upper pole access could not be used because of the high-lying kidney. In such patients, the lower or middle pole puncture was selected.

In the present data, the authors found that Group 1 patients underwent the procedure more times, and blood loss in this group was slightly higher than that in the other groups. Nevertheless, the differences among the three groups were not statistically significant, and surgeons opt for this approach for staghorn stone removal. In addition to the flexible nephroscope, the tipless nitinol stone basket and holmium, YAG laser effectively aid in the removal of the entire stone. The flexible nephroscope has become important for the removal of stones and to diagnose diseases in the upper tract. However, its use requires skill and experience of urologists.

The present study has some disadvantages because it is a retrospective and non-randomized study. Additionally, the sample size is small. Further investigation with a larger sample size will provide additional insight.

Conclusion

The estimated blood loss, length of hospital stay, number of procedures for complete stone-free status, operative time, complications of PCNL in renal stones >2 cm, and the clinical outcomes of surgery performed by the upper, middle, and lower calyceal approaches were not statistically significant.

Therefore, the best calyceal approach depends on the distribution of the stone, calyceal anatomy, and experience of the urologist.

Potential conflicts of interest

None.

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ตำแหน่งก้านไตที่เหมาะสมในการผ่าตัดรักษานิ่วที่ไตโดยวิธีเจาะนิ่วผ่านเนื้อไต

พลเทพ ชาญประสบผล, วิสูตร คงเจริญสมบัติ, เจริญ ลีนานุพันธุ์, กิตติณัฐ กิจวิกัย, วิทย์ วิเศษสินธุ์

วัตถุประสงค์: *เปรียบเทียบผลลัพธ์จากการผ่าตัดนิ่วผ่านเนื้อไต, ผ่านก้านไตส่วนบน, ส่วนกลาง และส่วนล่าง*

วัสดุและวิธีการ: *เป็นการเก็บข้อมูลย้อนหลังของผู้ป่วยที่เข้ารับการรักษานิ่วโดยวิธีการเจาะผ่านเนื้อไต ตั้งแต่ เดือนธันวาคม พ.ศ. 2549 ถึง มกราคม พ.ศ. 2553 จำนวน 92 ราย 92 ไต ของโรงพยาบาลรามาธิบดี โดยเลือกกลุ่มนิ่วที่มีขนาดมากกว่า 52 เซนติเมตรขึ้นไป และคัดออกในรายที่เป็นนิ่วขนาดเล็กกว่า 2 เซนติเมตร โดยแบ่งผู้ป่วยออกเป็น 3 กลุ่ม ตามตำแหน่งของก้านไต ที่ใช้กล้องส่องผ่านคือ กลุ่ม 1) ก้านไตส่วนบน (upper calyx) 2) ก้านไตส่วนกลาง (middle calyx) และก้านไตส่วนล่าง (lower calyx) และนำผลของการผ่าตัดทั้ง 3 กลุ่ม มาเปรียบเทียบกันในด้านการเสียเลือด, เวลาที่ใช้ในการผ่าตัด, จำนวนครั้งในการผ่าตัดจนนิ่วหมด และภาวะแทรกซ้อน ทั้ง 3 กลุ่ม*

ผลการศึกษา: *พบว่าระยะเวลาการนอนรักษาตัวในโรงพยาบาล, ปริมารการเสียเลือดจำนวนครั้งในการเข้ารับการผ่าตัดจนกระทั่งนิ่วหมด และระยะที่ใช้ในการผ่าตัดไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติในผู้ป่วยสามกลุ่ม ส่วนภาวะแทรกซ้อนพบว่าในกลุ่มที่ 1 มีนิ่วหลุดลงไปบริเวณท่อไต 2 ราย มีกรวยไตทะลุ และการติดเชื้อทางเดินปัสสาวะอย่างละ 1 ราย กลุ่มที่ 2 มี 1 ราย ที่มีการติดเชื้อทางเดินปัสสาวะ ส่วนกลุ่มที่ 3 มีภาวะแทรกซ้อน 5 ราย คือ 1 รายมีน้ำบริเวณท่อไต, 2 ราย มีเลือดไหลออกจากไตค่อนข้างมาก และ 2 ราย ที่เหลือมีการติดเชื้อทางเดินปัสสาวะ*

สรุป: *ปริมาณการเสียเลือด, ระยะเวลาการนอนรักษาตัวในโรงพยาบาล, จำนวนครั้งในการเข้ารับการผ่าตัดจนกระทั่งนิ่วหมด และภาวะแทรกซ้อนต่าง ๆ ไม่มีความแตกต่างกันอย่างชัดเจน ผลลัพธ์ออกมาได้ผลดี และภาวะแทรกซ้อนค่อนข้างน้อย การทำการรักษานิ่วโดยวิธีนี้จึงเหมาะสม แต่อย่างไรก็ตามยังมีองค์ประกอบที่สำคัญต่อผลการผ่าตัด คือ ความชำนาญของแพทย์ การกระจายตัวของนิ่วและกายวิภาคของก้าน, กรวยไต*