Percutaneous nephrolithotomy for complex renal calculi: is multi-tract approach OK?

Hyuk Jin Cho, MD, Ji Youl Lee, MD, Sae Woong Kim, MD,
Tae-Kon Hwang, MD, Sung-Hoo Hong, MD
Department of Urology, Seoul St Mary's Hospital, The Catholic University of Korea College of Medicine, Korea

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Introduction: *To compare the safety and efficacy of multiple-tract percutaneous nephrolithotomy (PCNL) with single-tract PCNL for complex renal stones.*
Materials and methods: *A total of 109 consecutive PCNL procedures for unilateral complex renal calculi (staghorn or complex caliceal calculi) were performed at our institution. Thirty patients received multiple-tract PCNL and 79 patients underwent single-tract PCNL. The two groups had comparable demographic data except for a smaller stone burden and fewer complete staghorn calculi in those undergoing single-tract PCNL. Variables of interest included operative time, blood loss, change of serum creatinine, transfusion rates, length of hospital stay, stone clearance, number of ancillary procedures, and complication rates.*
Results: *The number of tracts used for multiple-tract PCNL was two tracts in 20 patients, three tracts in 9, and four tracts in 1. Significant differences were not observed when the single-tract PCNL results were compared with the multiple-tract PCNL in terms of success rate, operative time, transfusion rate, drop in hemoglobin, hospitalization time, complication rate, and rise in serum creatinine. The need for ancillary procedures was more common in patients undergoing multiple-tract PCNL (53.3% versus 24.1%; p = 0.003). No long-term sequela were noted during the median follow up of 24 months in any patient.*
Conclusions: *The results of the present study show that multi-tract PCNL for appropriately chosen stones/patients has similar safety and effectiveness as single PCNL in patients with smaller and less complex stones.*

Key Words: percutaneous nephrolithotomy, kidney calculi, treatment outcome, complications

Introduction

Percutaneous nephrolithotomy (PCNL) has been established as a highly effective treatment alternative that is commonly used to treat patients with large or complex renal stones.[1] PCNL is preferred over open stone surgery because it is associated with lower morbidity, greater postoperative comfort, and is more cost-effective.[2] The American Urological Association Nephrolithiasis Clinical Guidelines panel recommended percutaneous stone removal as the first-line treatment choice for the management of staghorn calculi.[3] With increasing stone size and complexity, PCNL can require a longer operative time, a larger volume of irrigant fluid, and multiple tracts to achieve optimal stone clearance.[1,4-5] Many urologists hesitate

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Address correspondence to Dr. Sung-Hoo Hong, Department of Urology, The Catholic University of Korea College of Medicine, 505, Banpo-dong, Seocho-gu, Seoul 137-701, Korea

to place more than two to three tracts during PCNL procedures due to potential injury to the pelvicaliceal system, resulting in an excessive amount of bleeding.

Herein, the outcomes of patients requiring multiple percutaneous access tracts were compared to patients requiring a single tract in a specific subset of patients with large complex renal calculi.

Materials and methods

Between July 2003 and December 2008, 234 PCNL procedures were performed at our institution by a single surgeon; among these cases, 109 patients were treated with percutaneous techniques for complex renal calculi, including 30 multiple (two or more) tract procedures (group 1) and 79 single tract procedures (group 2). This study was approved by our Institutional Review Board. Patients that had bilateral PCNL and a history of failed shockwave lithotripsy (SWL) or open renal surgery on the same side were excluded from the study. Stone size was assessed as the surface area and calculated using the longitudinal and transverse diameters.[6]

Preoperative complete blood counts, serum creatinine, platelet counts, bleeding and coagulation profiles, and urine cultures were obtained in all patients, while the radiological evaluation included intravenous urography and/or urinary tract ultrasonography, with the addition of non-contrast computed tomography in selected cases. Stone burden was determined by radiological studies, and the stones were classified as complex (partial or complete staghorn stones, renal pelvis stones accompanying caliceal stones, several calculi within different calices), regardless of their size. Antibiotics were administered prophylactically to all of the patients.

At our institution, percutaneous access is obtained at a single setting by a urologist in the operating room with c-arm fluoroscopy. Under general anesthesia, ureteral catheterization was performed on the ipsilateral side, and the patient was placed in the prone position with all pressure points padded. Renal access was predetermined after studying the stone configuration with respect to the intrarenal collecting system anatomy. The main tract was the one through which the maximal stone burden could be cleared. When multiple tracts were anticipated, all punctures were usually made at the outset and preplaced wires were put into the collecting system or down the ureter. Tract dilatation was accomplished using Amplatz or balloon dilators of up to 24 Fr or 30 Fr. Fragmentation and stone removal were carried out in all patients using pneumatic or ultrasound energy and retrieval graspers through a rigid 22 Fr or 26 Fr nephroscope. A holmium laser and flexible nephroscopes were not used. After the procedure was completed, a 20 Fr nephrostomy tube was inserted in all patients. The need for a blood transfusion was decided on the basis of the postoperative hemoglobin. Stone clearance was documented on plain abdominal x-rays or computerized tomography (CT) based on the stone composition in the next morning. In patients with complete stone clearance, the nephrostomy tubes were clamped and subsequently removed the next day.

A double-J catheter was considered if urine drainage from the tract persisted for more than 24 h after the removal of the nephrostomy tube. The nephrostomy tube was left in place if a second PCNL session due to residual stones was planned. Re-PCNL, ureteroscopy, SWL were considered as additional treatment alternatives when indicated. Patients were followed at 1 week, 1 month, and then 3 months, with a median follow up period of 12 months. During each follow up visit we checked the patient's condition, urinalysis, and x-ray. For some selected patients we performed CT.

Results were classified as 'stone-free', presence of 'clinically insignificant residual fragments (CIRF)', and 'unsuccessful (presence of residual stones)'. CIRFs were considered ≤ 4 mm, non-obstructing, non-infectious, and asymptomatic residual fragments. The PCNL procedure was considered successful if the patient was either stone-free or had CIRFs.

The preoperative clinical data, intraoperative data, and postoperative outcomes were all compared using the chi-square test for qualitative variables and the Student t test for quantitative variables. A p value < 0.05 was considered statistically significant.

Results

Table 1 lists the patient demographics and stone characteristics. The mean patient age, gender distribution, body mass index (BMI), and stone laterality were similar in the two groups. The multiple-tract group had a greater stone burden, and was predominantly composed of complete staghorn calculi (63.3%). The number of tracts required per patient in group 1 was two among 20 patients, three in 9 patients, and four in 1 patient, for a total of 71 tracts. On average, 2.4 nephrostomy tracts were used in the multiple-tract PCNL procedures.

The surgical and hospitalization data are listed in Table 2. No significant difference was found in the blood loss, analgesic requirement, drop in hemoglobin, change in serum creatinine, or length of stay between

TABLE 1. **Patient characteristics**

Parameters	Group 1 (multiple-tract) [n = 30]	Group 2 (single-tract) [n = 79]	p value
Number male (%)	15 (50)	46 (58.2)	0.44
Mean age ± SD	51.8 ± 14.8	53.9 ± 14.6	0.49
Right/left	1.8	1.6	0.32
BMI (kg/m^2)	21.7 (16.7-26.6)	22.4 (17-27.5)	0.19
ASA score	1.57	1.23	0.63
Mean stone size ± SD (mm^2)	1789.9 ± 1058.5	883.0 ± 779.9	0.001
Number complete staghorn stones (%)	19 (63.3)	22 (27.8)	0.001

BMI = body mass index; ASA = American Society of Anesthesiologists.

the two groups. On the first postoperative day, the mean visual pain analog score was 7.2 in group 1 and 6.4 in group 2 patients (p = 0.06). The mean operative time was similar in the two groups for each operation, totaling 164 minutes for group 1 (range 60-420 minutes) and 146 minutes for group 2 (range 60-300 minutes). The overall success rate for the multiple-access group was 86.7% compared to 93.7% for the single-access

TABLE 2. **Peri and postoperative data**

Parameters	Group 1 (multiple-tract) [n = 30]	Group 2 (single-tract) [n = 79]	p value
Site of puncture (%)			0.32
Upper calyx	21 (29.5)	31 (39.2)	
Mid calyx	23 (32.4)	18 (22.8)	
Lower calyx	27 (38.0)	30 (38.0)	
Analgesic requirement (tramadol) mg	210 (100-300)	170 (100-250)	0.07
Mean mins operative time ± SD	164.6 ± 77.6	146.4 ± 54.2	0.17
Mean days hospitalization	7.3 (5-10)	7.1 (4-23)	0.76
Mean days nephrostomy removal	5.6 (3-12)	5.4 (3-22)	0.79
EBL (mL)	378 (100-570)	292 (70-490)	0.28
Success rate			
Initial success rate (%)	15 (50.0)	59 (74.7)	0.01
Final success rate (%)	26 (86.7)	74 (93.7)	0.23
Ancillary treatment (%)	16 (53.3)	19 (24.1)	0.003
SWL	12 (40)	14 (17.7)	
PCNL	3 (10)	5 (6.3)	
URSL	1 (3.3)	0	
Drop in Hb (g/dL)	2.2 ± 1.7	1.5 ± 1.1	0.06
Mean Scr Change (mg/dL)	0.08 ± 0.12	0.05 ± 0.22	0.56

EBL = estimated blood loss; SWL = shock wave lithotripsy; PCNL = percutaneous nephrolithotomy; URSL = ureterorenoscopic lithotripsy.

TABLE 3. **Complications**

Parameters	Group 1 (multiple-tract) [n = 30]	Group 2 (single-tract) [n = 79]	p value
Major complications (%)	3 (10.0)	5 (6.3)	0.51
Hemorrhage requiring exploration	2		
Death (septic shock)		1	
Perinephritic abscess formation		1	
Perforation of upper urinary tract	1	1	
Prolonged urine drainage (insertion of double-J stent)		2	
Minor complications (%)	10 (33.3)	19 (24.1)	0.32
Postoperative fever (> 38°C)	4 (13.3)	9 (11.4)	0.78
Transfusion	6 (20.0)	10 (12.7)	0.33
Total	13 (43.3)	24 (30.4)	0.20

group (p = 0.23). In the multiple-tract group, the success rate was 50.0% after one session of PCNL, with 15 having significant residues. In these 15 renal units, three cases required a second-look PCNL, 12 required SWL, and one required ureterorenoscopy. In patients managed with single access procedures, the success rate was 74.7% for a single session. This rate increased to 93.7% after a second intervention (5 second-look PCNL, and 14 SWL). A larger percentage of patients in group 1 underwent ancillary treatment.

The perioperative complications are listed in Table 3. There was no significant difference in overall complication rates between the two groups. Fever (temperature above 38°C) was detected in four (13.3%) patients in group 1 and in nine (11.4%) patients in group 2. All patients recovered well with intravenous antibiotics and other supportive measures. A blood transfusion was indicated in 12.7% of patients managed by single access, and in 20.0% of patients managed by multiple access procedures (p = 0.33). For two patients in the multiple-tract group, open surgery was performed. The patient with three-tract that underwent nephrectomy, became hemodynamically unstable on the day of the surgery so we went into open surgery immediately. During the surgery there was parenchymal tear, so renorrhapy was performed but hemostasis was not achieved so nephrectomy was performed. For the other patient with two-tract that underwent renorrhaphy, selective angioembolization was performed but hemostasis was not controlled so renorrhaphy was performed. One patient died in group 2 due to post-procedure sepsis. One patient in each group had a ureteral laceration, which was managed conservatively with prolonged double-J catheter placement. One patient in the single-tract group had a perinephric abscess that was treated with aspiration only, and two patients required double-J placement due to prolonged urine leakage from the percutaneous tract for longer than 24 hours after removal of the nephrostomy tube.

Discussion

Complex and staghorn calculi with multiple caliceal involvement often require multiple tracts to achieve successful clearance and to reduce the necessity of secondary procedures such as SWL. However, multiple-tract procedures have been associated with increased bleeding and transfusion rates.[4,5,7-9]

The objective of this study was to evaluate the safety and efficacy of multiple-tract PCNL in patients with complex renal calculi by comparing them with single-tract PCNL. Various authors have compared the effectiveness of multiple-tract PCNL in patients with large renal stones. Aron and coworkers[1] presented their series on complete staghorn calculi in 121 renal units treated via a total of 397 percutaneous tracts. Despite a major complication rate of 19.8%, they achieved a 94% stone-free rate during follow up; they advocated aggressive PCNL therapy for the management of complex renal calculi. They concluded that aggressive PCNL monotherapy using multiple tracts was safe and effective and should be the first option considered for massive renal staghorn calculi. Hegarty and Desai[4] prospectively compared the outcomes of PCNL with a single tract versus multiple tracts (n = 20 in each group), and noted a mean drop in hemoglobin in patients with multiple tracts that

was similar to patients that needed a solitary tract; the use of multiple tracts did not lead to a higher frequency of complications. Complete clearance was achieved in 95% of the cases. Therefore, monotherapy with PCNL utilizing multiple percutaneous tracts was very effective for the treatment of staghorn and other large-volume renal calculi. A recent large-scale study, also showed no difference in the stone-free status and complication rate between single-tract and multiple tract-PCNL (86.4% versus 84.1%, and 4.6% versus 5%, respectively).[9]

In the present study, an overall success rate of 86.7% for multiple-tract PCNL and 93.7% for single-tract PCNL was achieved. These results correlated with a previously published series. However, there was significantly higher rate of ancillary procedures in the patients with multiple-tract PCNL. In patients managed with multiple punctures, the success rate was lower than the single access group after a single session of PCNL; this was probably due to the difference in the mean stone burden between the two groups. In addition, we had to terminate surgery in two patients due to hemorrhage interfering with the surgical field and deteriorating hemodynamics of the patient, which may also contribute to the lower initial stone-free rates. Due to equipment limitations, flexible nephroscopy/ureteroscopy and holmium laser lithotripsy were not used in all of the subjects. If this equipment was available for all patients the success rate might have been higher and reduced the need for ancillary procedures.

The results of this study showed that the use of multiple tracts did not lead to a higher frequency of complications including transfusions, with an overall complication rate of 43.0% and 30.4% in multiple- and single-tract PCNL, respectively. These are comparable to the previously reported 30%-45.5% complication rate of multiple-tract PCNL.[4,5,7] Bleeding necessitating blood transfusions is still the most common and worrisome complication of percutaneous renal surgery. In the study reported by Hegarty and associates,[4] blood transfusion was required in 20% of patients that had multiple-tract PCNL. The investigators stated that the need for a transfusion correlated with a lower preoperative hemoglobin and higher preoperative serum creatinine levels. In addition, there was a significant rise in serum creatinine and a drop in creatinine clearance in the multiple-tract group; this was more common in patients with renal insufficiency. Contrary to this prior report, there was no significant change in the serum creatinine, in this study. In the multiple-access group, a creatinine level greater than 1.4 mg/dL during the early postoperative period was detected in only one patient. In the study reported by Desai et al,[9] a blood transfusion was required in 12.4% and 8.4% of patients undergoing multi-tract and single-tract surgery, respectively. The mean drop in hemoglobin and the transfusion rate was 2.2 g/dL and 20.0% with the multiple access tract procedure in this study. These findings were similar to the single tract procedures. The difference in blood loss between procedures requiring two tracts (2.0 g/dL ± 1.9 g/dL) and those needing three tracts (2.7 g/dL ± 1.4 g/dL) was not significant ($p = 0.09$). Although not statistically significant, there was a trend toward more blood loss with multiple tract PCNL procedures. This is likely attributable to the small number of patients requiring multiple-tract access in this cohort; most patients require two or three percutaneous tracts (96.9%) during a single procedure.

It has also been recognized that most of the postoperative pain and morbidity associated with PCNL are caused by nephrostomy tubes.[10] However, we found that there was no significant difference in the postoperative pain and analgesic requirement between the two groups. Patients subjected to multiple-tract PCNL had a similar hospital stay and duration of nephrostomy compared to the patients with single tracts. There was one operative mortality that occurred due to infectious complications, in the single-tract group. Two patients in the single tract group experienced prolonged urine leakage, resulting in stent insertion; one patient with severe edema in the ureteropelvic junction, and the other patient that has a tiny residual stone that migrated to the lower ureter. The stent was removed two weeks later for both patients, resulting in full recovery.

If carefully performed multiple tracts do not significantly increase the intraoperative complications or transfusion requirements. When planning to proceed with a multiple- or single-tract PCNL, the anatomy of the collecting system, namely the angle, length, and width of the infundibulum should be considered in addition to the stone burden. Using multiple tracts prevents excessive torque to gain entry into adjacent calyces, which may cause infundibular tearing and bleeding. It is widely accepted that to establish an optimal percutaneous tract is a critical step in PCNL procedures for complete clearance of calculi.[11] In this series, percutaneous access was obtained by the urologist in all cases. All possible tracts were punctured right at the outset. The access that was more likely to clear most of the stone burden (usually in the upper pole) was dilated first, and the additional accessory tracts were dilated subsequently. The upper caliceal tract was quite often supracostal.

Although upper pole access was used in 29.5% for multiple-tract PCNL procedures and 39.2% of single-tract PCNL procedures, hydropneumothorax was not observed in the present series.

The limitations of this study include the following. Data were analyzed retrospectively and not completely controlled for patient characteristics; a selection bias is inherent in all retrospective studies. Therefore, further prospective studies are necessary. Another limitation of the study was that all of the patients were not assessed postoperatively by computerized tomography but were generally followed by urography or plain (KUB) radiography, which may have overestimated the stone-free rate.

Conclusion

In this study on select group of complex stones, we have found that the need for ancillary procedures was more common in patients undergoing multiple-tract PCNL, multi-tract PCNL for appropriately chosen stones/patients has similar safety and effectiveness as single PCNL in patients with smaller and less complex stones. □

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