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Comparison of Outcomes After Percutaneous Nephrolithotomy of Staghorn Calculi in Those with Single and Multiple Accesses

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Abstract

Purpose: To analyze the early outcome after single tract *vs* multiple tracts percutaneous nephrolithotomy (PCNL) in the management of staghorn calculi.

Patients and Methods: The records of 413 patients with staghorn calculi (223 [54%] had complete and 190 [46%] had partial) who underwent PCNL were reviewed retrospectively. A total of 244 (59%) patients were managed by single access (group 1); meanwhile, multiple accesses were necessary in 169 (41%) patients (group 2). Both groups were compared in terms of perioperative findings and postoperative outcomes. Patients and stone-related factors affecting the number of accesses performed were analyzed.

Results: The mean number of percutaneous accesses was 2.42 ± 0.74 (range 2–6) in group 2. Mean durations of fluoroscopy screening time and operative time were significantly longer in group 2 ($P = 0.002$, $P < 0.0001$, respectively). Supracostal access was necessary in 30.7% in group 2 and in 6.9% in group 1 ($P = 0.001$). Success was achieved in 70.1% in group 1 and in 81.1% for group 2 after one session of PCNL ($P = 0.012$). The most common complication was bleeding for both groups, and it was higher in group 2 ($P < 0.0001$). The mean preoperative and postoperative creatinine concentrations were 1.03 mg/dL and 1.08 mg/dL in group 1, and 0.9 mg/dL and 1.03 mg/dL in group 2, respectively. The mean changes in creatinine values were not statistically significant between the groups ($P = 0.16$).

Conclusions: The impact of PCNL using either single or multiple access tracts on renal function is similar and of a temporary nature. PCNL with multiple accesses is a highly successful alternative with considerable complication rates in the management of staghorn calculi.

Introduction

Staghorn calculi are branched and generally infected stones that occupy a large portion of the collecting system.[1] Failure to eliminate complex staghorn stones presumably destroys the kidney parenchyma and causes sepsis as well as complete loss of function. Therefore, complete removal of the stones to eradicate causative organisms, reduce obstruction, and prevent further stone growth is the main target in the management of these cases.

Currently, complex staghorn calculi have been mostly managed with percutaneous nephrolithotomy (PCNL).[2] The morbidity of PCNL is seen less than open surgery with better stone-free rates.[2] PCNL, however, necessitates a longer operative time, larger volumes of irrigation fluid, and multiple tracts to achieve a complete stone-free rate in cases with increased stone size and complexity.

On the other hand, creation of multiple percutaneous tracts has the potential risk of bleeding and higher complication rates compared with procedures using single tracts.[3] In this study, we compared the outcomes in patients needing multiple or single percutaneous access tracts with respect to etiologic factors for bleeding, transfusion requirement, complications, and early postoperative renal function. Furthermore, we investigated the effects of patients and stone-related factors on the number of accesses.

Patients and Methods

We retrospectively reviewed the records of 413 consecutive patients who had undergone PCNL for staghorn calculi at our institution between October 2002 and February 2009. Intravenous urography (IVU) and/or CT were performed in all patients. Patients' demographics, including age, sex, body

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mass index (BMI), and stone burden[4] were recorded. Preoperative laboratory tests included serum creatinine and hemoglobin (Hb) measurements, platelet counts, coagulation screening tests, and urine cultures. All patients had either a sterile urine culture or were treated according to the antibiotic sensitivity tests preoperatively.

The stones were either complete staghorn stone (occupying the renal pelvis and all of the caliceal system or filled $\geq$80% of the renal collecting system) or partial staghorn stone (filled the renal pelvis or at least two or more calices).[5]

Each patient underwent PCNL, beginning with cystoscopy and insertion of a ureteral catheter, as previously described.[6] Briefly, patients were then placed in the prone position, and percutaneous access was obtained by the attending urologist at a single setting using C-arm fluoroscopy. After proper caliceal puncture, the tract was dilated with a high-pressure balloon dilatator (Nephromax,® Boston Scientific, Natick, MA) and a 30F Amplatz sheath was placed.

Nephroscopy was performed with a rigid 26F nephroscope. Additional tracts were created, when indicated, in the same session. Stones were fragmented using either a pneumatic lithotripter (Vibrolith,® Elmed, Ankara, Turkey) or an ultrasonic lithotripter (Lithoclast,® EMS, Nyon, Switzerland). In patients with residual stones, additional accesses were obtained at the same session. When the angle was suitable, Y-tract access was performed using the same incision.[7] Flexible nephroscopy was performed at the end of the procedure in patients with suspected residual stones (ACMI digital (Southborough, MA, and Karl Storz, Tuttlingen, Germany). Stone clearance and the integrity of the collecting system were confirmed intraoperatively by fluoroscopy and antegrade nephrostography. A 14F nephrostomy tube was placed into the renal pelvis or the involved calix at the conclusion of the procedure. If doubt about complete clearance or bleeding from other tracts existed, additional nephrostomy tubes were placed.

The strategy of our clinic for blood transfusion was often according to perioperative status, and it was usually initiated intraoperatively. In addition, indication for transfusion in the early postoperative period (48 hours after the procedure) included symptomatic anemia and/or a hematocrit (Hct) of less than 30% and Hb levels of less than 10 g/dL. The approximation that a 1 unit of blood transfusion increases the Hb level by 1 g/dL and hematocrit by 3% was used to factor the influence of blood transfusions. Drops in Hb and Hct levels were calculated as: ([preoperative Hb (Hct)−postoperative Hb (Hct)]−[number of units transfused * 1 g/dL (3% for Hct) Hb per unit transfused]).

On the first or second postoperative day, all patients underwent routine plain radiography and retrograde nephrostography to check for residual stone fragments, urinary leakage, and infrarenal obstruction. If the radiologic study did not reveal any residual stone and showed a patent tract, the nephrostomy tube was removed. If residual calculi $\geq$5 mm were present, a second PCNL or extracorporeal shockwave lithotripsy (SWL) was considered. The second session PCNL is scheduled with a mean interval of 1 to 3 months. Serum creatinine levels and blood counts were obtained in all patients postoperatively. All patients were evaluated with IVU and/or helical CT 3 months after the operation. Success was defined as complete stone clearance.

Statistical analysis was performed with SPSS 11.5 Windows software (SPSS Inc, Chicago, IL). Continuous variables were compared with the Student *t* test, Mann Whitney-U test, and Wilcoxon test, as appropriate. Proportions of categorical variables were analyzed for statistical significance using the chi-square test or the Fisher exact test.

Results

A total of 413 patients with staghorn calculi, including 246 males and 167 females, were treated with PCNL (Table 1). The mean stone area was 12.06 cm^2 (range 4–35 cm^2). Of the 413 patients, 223 (54%) had complete and 190 (46%) partial staghorn calculi. A total of 244 (59.1%) patients were treated with single access (group 1), and the remaining (40.9%) patients underwent multiple accesses PCNL (group 2). In group 2, a mean of 2.42 ± 0.74 (range 2–6) access tracts were created as follows: Two accesses in 118 (69.8%) cases; three in 36 (21.3%) cases; four in 11 (6.5%) cases; five in 3 (0.7%) cases, and six accesses in 1 (0.2%) case. The mean age of the patients, stone size, BMI, and grade of hydronephrosis were similar between groups (Table 1). The incidence of previous open surgery was found to be lower in group 1 than group 2. The mean duration of nephroscopy and also operative time were significantly longer in group 2 ($P = 0.011$, $P = <0.0001$, respectively). Supracostal access was necessary in 30.7% of the patients in group 2 and only in 6.9% of the cases in group 1 ($P = 0.001$) (Table 1).

Total complication rates are given in Table 1. The percentages of access-related complications were significantly different between groups. The most common complication was bleeding, and the rate of this complication was significantly higher in group 2. The necessity for blood transfusion was greater in group 2 (28.4% *vs* 13.9%, $P = 0.001$). A Double-J stent was inserted in 0.8% (n = 2) of the patients in group 1, and in four (2.4%) patients in group 2 because of pelvicaliceal system perforation or persistent leakage of urine after removal of the nephrostomy tube. Urosepsis was encountered in two (0.8%) and five (3.0%) patients in groups 1 and 2, respectively. All patients were successfully treated with intravenous antibiotics. Hydrothorax that necessitated insertion of a chest tube developed in three (1.2%) and seven (4.1%) patients who were treated with single tract or multiple tracts PCNL, respectively.

The mean preoperative and postoperative Hb values were 13.7 ± 1.8 g/dL *vs* 13.6 ± 1.9 g/dL and 11.6 ± 1.7 g/dL *vs* 11.2 ± 2.0 g/dL in groups 1 and 2, respectively. Postoperative Hb values were significantly lower than preoperative levels in both groups ($P < 0.0001$ for each group). The mean drop in postoperative Hb level, however, was significantly higher in group 2 than group 1 ($P = 0.01$) (Table 2).

The mean preoperative and postoperative creatinine concentrations were 1.03 mg/dL and 1.08 mg/dL in group1, and 0.9 mg/dL and 1.03 mg/dL in group 2, respectively (Table 2). The differences between preoperative and postoperative mean creatinine concentrations were statistically significant in both groups. The mean changes in creatinine values, however, were not statistically significant between the groups. Acute renal failure developed in two patients in both groups.

Success was achieved in 70.1% for group 1 and 81.1% for group 2 after one session of PCNL ($P = 0.012$), while 60 and 17 patients had significant residue in groups 1 and 2, respectively. As an auxiliary treatment, PCNL was again performed in 13 and 5 patients in group 1 and group 2, respectively. A

Table 1. Clinical Characteristics, Morbidities, and Complications of Each Group

Parameters	*Group 1*	*Group 2*	P *value*
Clinical characteristics	% (n)	% (n)	
Sex			0.89
Male	59.8 (146)	59.2 (100)	
Female	40.2 (98)	40.8 (69)	
Previous open surgery	22.5 (55)	34.3 (58)	0.008
Mean age	43.5 ± 14.4	40.8 ± 14.0	0.19
History of SWL	18.9 (46)	23.1 (39)	0.29
Grade of hydronephrosis			0.34
G 0	3.7 (9)	1.2 (2)	
G I	21.3 (52)	18.3 (31)	
G II	54.9 (134)	60.4 (102)	
G III	20.1 (49)	20.1 (34)	
Side (left)	54.5 (133)	50.9 (86)	0.46
Intercostal access	6.9 (17)	30.7 (52)	< 0.0001
BMI			0.32
<25 kg/m^2	40.6 (99)	47.3 (80)	
25– <30 kg/m^2	38.9 (95)	36.7 (62)	
≥30 kg/m^2	20.5 (50)	16.0 (27)	
Stone size			0.53
<4 cm^2	3.7 (9)	1.8 (3)	
4–10 cm^2	41.0 (100)	40.8 (69)	
>10 cm^2	55.3 (135)	57.4 (97)	
Morbidities	Mean ± SD (range)	Mean ± SD (range)	
Mean duration of fluoroscopy (min)	8.67 ± 5.03 (1–46)	10.88 ± 6.84 (2–44)	0.002
Mean operative time (min)	70.04 ± 27 (15–180)	82,14 ± 32.14 (35–210)	< 0.0001
Mean hospital stay (day)	3.02 ± 1.91 (1–17)	3.53 ± 2.55 (2–21)	0.002
Mean nephrostomy time (day)	2.89 ± 1.68 (0–15)	3.19 ± 1.79 (2–15)	0.011
Complication	% (n)	% (n)	
Pelvicaliceal system perforation or persistent leakage of urine	0.8 (2)	2.4 (4)	0.32
Hydrothorax	1.2 (3)	4.1 (7)	0.09
Urosepsis	0.8 (2)	3.0 (5)	0.12
Transfusion needed because of bleeding	13.9 (34)	28.4 (48)	< 0.0001

SWL = shockwave lithotripsy; BMI = body mass index; SD = standard deviation.

stone-free state was achieved in 11 of 13 patients in group 1 and 4 of 5 patients in group 2 after second-session PCNL. Finally, the success rate improved to 74.5% for group1 and 83.4% for group 2 ($P = 0.04$). SWL was performed in 41 (16.8%) and 12 (7.1%) patients in group 1 and group 2, respectively, Furthermore, ureterorenoscopic lithotripsy was performed in six (2.6%) cases in group 2. In groups 1 and 2, 13 and 15 renal units with borderline residues were followed up, respectively. At the end of the mean 9.4 months of follow-up, after including auxiliary treatment, 92.4% did not need any further treatment. The mean hospital stay, fluoroscopy screening time, and duration of nephrostomy were shorter in group 1 (Table 1).

Discussion

According to the guidelines published by the American Urological Association (AUA), PCNL has many advantages: If the stone can be seen, it can almost always be eliminated; the collecting system can be inspected directly so that small fragments can be identified and removed; because the tract can be kept open indefinitely, repeated inspections are possible; and success or lack of success of the procedure is usually readily apparent.[2] Therefore, PCNL is recommended by AUA as the most appropriate treatment option for most patients with large-volume renal staghorn calculi. With this procedure, in various publications, stone-free rates, incidence of acute complications, and the requirement for an auxilliary procedure have been reported to be 74% to 83%, 0% to 15%, and 14% to 24%, respectively.[2] The need for multiple accesses and supracostal accesses, however, are the most scaring or stressful manipulations during percutaneous surgery.

When dealing with staghorn calculi, both the patients and the theater staff have to be prepared for multiple tract/

Table 2. Comparison of Effect of Percutaneous Nephrolithotomy on Hemoglobin and Serum Creatinine Levels

Parameters	*Group 1*	*Group 2*	P *value*
Preop Hb	13.7 ± 1.8	13.6 ± 1.9	0.54
Postop Hb	11.6 ± 1.7	11.2 ± 2.0	0.02
Hb dropped	2.1 ± 1.7	2.5 ± 1.6	0.01
P value	< 0.0001	< 0.0001	
Preop Cre	1.03 ± 0.48	0.9 ± 0.2	0.46
Postop Cre	1.08 ± 0.46	1.03 ± 0.37	0.46
Cre increased	0.05 ± 0.30	0.06 ± 0.23	0.16
P value	0.001	< 0.0001	

Preop = preoperative; Hb = hemoglobin; postop = postoperative; Cre = creatinine.

percutaneous surgery with its specific characteristics, such as prolonged fluoroscopy and operative time as well as need for special surgical expertise, considerably increased risk for complications such as bleeding and pleural injury, and for the possibility of the need for auxilliary treatment to achieve complete staghorn calculi. In the present study, the effects of patients and stone-related factors on the number of access were investigated. Among preoperative clinic parameters, only the incidence of previous open renal surgery was found to be significantly higher in the multiple accesses group. No significant relationship, however, was observed between the number of the accesses and other factors such as patient age, stone size, grade of hydronephrosis, BMI, and sex. Margel and associates[8] compared patients with or without previous open surgeries. They reported that patients in the previous renal surgery group needed more attempts to gain access into the collecting system (2.3 ± 1.9 *vs* 1.2 ± 1.1, respectively). This relative increase may be associated with alteration of anatomic architecture of the kidney after previous renal surgery. A scarred kidney and the typical stiffness of the scarred collecting system may be the cause of difficult access in patients with previous open renal surgeries. Studies indicate, however, that the history of previous renal surgery does not affect the success of PCNL.[9]

Similar to the present study, primary fluoroscopic guidance for percutaneous nephrostomy creation is the preferred technique by most investigators.[10,11] Creating a percutaneous renal access, which sometimes necessitates longer fluoroscopy time than the other steps of PCNL, is the initial and probably the most important step of the PCNL. The mean duration of fluoroscopy was found to be longer in PCNL with multiple tracts. The maximum yearly whole-body exposure as recommended by the National Commission on Radiation Protection is 5 rem.[12] The urologist can safely perform 35 procedures per month within these limits.[13]

Bleeding that necessitates transfusion was more common in the multiple access group (13.6% *vs* 28.4%; $P = 0.001$). Netto and colleagues[14] treated 119 patients with staghorn calculi using PCNL. They compared upper pole (13.4%), lower or middle caliceal (58.8%), and multiple renal access (27.7%) groups. The stone-free rates were reported as 87.5%, 80.0%, 84.8% for each group, respectively. Authors reported that transfusion necessity was significantly higher in the multiple access group. According to a multivariate regression analysis that was performed by Kukreja and coworkers,[3] diabetes mellitus, multiple-tract procedures, and prolonged operative time were related to significantly increased blood loss.[3] Similarly, Muslumanoglu and colleagues[6] detected that using multiple and supracostal access tracts significantly increased complication rates. On the other hand, Hegarty and Desai[15] reported that the mean drop in Hb levels was similar in patients who had undergone PCNL needing single ($n = 20$) or multiple ($n = 20$) accesses. Although authors reported a correlation between necessity for transfusion and preoperative Hb values, their study was limited to a small number of patients in each group.

Access to the upper-pole calix can be difficult through the subcostal route. For supracostal upper-pole access, the puncture site was localized in the midpoint of the 11th and 12th intercostal spaces, usually 1 to 2 cm cranial to the upper pole of the most medial calix. The rate of pulmonary complications was higher with supracostal access. All patients in whom hydrothorax developed had previously undergone PCNL through supracostal access. In the majority of studies,[16,17] however, supracostal upper-pole access is preferred because of high stone-free rates with acceptable rates of complications. The advantages of direct upper-pole access is to have good exposure to the majority of the calices and renal pelvis, the possibility to reach the ureteropelvic junction and upper ureter, and the ability to operate along the long axis of the kidney, which causes less torque of the rigid nephroscope and ultimately less bleeding. Therefore, we do not hesitate to perform an upper-pole access when indicated.

In the present study, success rates were significantly higher in the multiple access group for one-session PCNL (70.1% *vs* 81.1%, $P = 0.012$). Alternatively, a combination of flexible ureteroscopic technique with simultaneous single percutaneous access is suggested instead of multiple accesses. Marguet and associates[18] reported early experience in the management of complex renal calculi necessitating multiple access tracts, using a combined ureteroscopic and percutaneous approach through a single tract. Investigators concluded that although combined PCNL and ureteroscopic management can effectively reduce the number of the access tracts, this combined procedure does not significantly affect the stone-free life span and operative time.

In a very recent prospective nonrandomized study in which PCNL was combined with a single lower caliceal puncture and flexible nephroscopy in 26 patients with complex renal stones, the overall stone-free rate was reported to be 74.8%, and perforation of the pelvicaliceal system occurred in 2 patients (11.5%) with no serious sequelae.[19] In our experience, access through a lower calix into the upper and middle calix is difficult and necessitates longer operative and fluoroscopy time. Consequently, the use of flexible nephroscopy may reduce the necessary number of accesses. To be able to interpret these outcomes, comparison of the combination of a single-access approach with retrograde flexible ureteroscopy or flexible nephroscopy techniques with a multiple-access approach in staghorn calculi should be conducted in further series, including a large number of patients.

Furthermore, a second-look procedure using the same tract is also an important part of the percutaneous management of staghorn calculi.[20] Because of the health policies of the government, however, the secondary procedures were postponed for 1 to 2 months later, and therefore were termed as re-PCNL procedures, which were generally performed using a new tract.

In the management of staghorn calculi with PCNL, the most stressful part is performing multiple accesses with potential risks related to the access number and location. The main object of this article was to compare the early outcome after single *vs* multiple tract PNL procedures in terms of success, complication rates, and renal functions in the early postoperative period. Our retrospective comparison revealed that early renal function is not significantly and clinically affected by multiple tracts. Serum creatinine levels decreased in 31%, remained unchanged in 18.4%, and increased in 50.6% of the patients. A creatinine level more than 2.0 mg/dL in the early postoperative period was detected in only four patients who had normal creatinine levels (<1.4 mg/dL) preoperatively.

Canes and coworkers[21] evaluated the impact of PCNL on the renal function in 81 patients with a solitary kidney. They reported an increase in the creatinine level from preoperative 1.78 ± 0.87 mg/dL to postoperative 1.87 ± 0.89 mg/dL. Postoperatively, however, increased levels dropped to preoperative levels at 1 month and 1 year after surgery. In addition, the authors indicated that renal function was preserved and in fact slightly improved; a statistically significant improvement in glomerular filtration rate occurred at the postoperative first year and worsened in only 6.8% of patients with a solitary kidney who had been treated with PCNL. Protection or improvement of renal functions has been reported after PCNL in various studies. Mayo and associates[22] investigated renal functions with radionuclide (dimercapto-succinic acid) studies and creatinine clearance estimates in 15 patients with a normal contralateral kidney 2 to 3 months after PCNL and found improved function, particularly in patients with infection stones. Also, scarring that resulted from creation of a nephrostomy tract is small compared with overall renal volume and does not cause changes in renal function.[23] Finally, an increase in creatinine levels at an early postoperative period is temporary and may be associated with anesthetic agents and medications such as antibiotics and hydrodistention during the operation.

Generally, morbidities occurred at a higher rate in patients with multiple access tracts. The mean hospital stay and duration of nephrostomy were longer in the multiple tract group. Complications, however, are usually self-limited, and success rates are significantly higher.

The present study has some limitations that merit mentioning. Although, PCNL with Y-tract technique was performed in most of the applicable cases, the present study lacks the data regarding patients who were treated with Y-tract technique. Liatsikos and coworkers[7] published their experience on angular percutaneous renal access in 100 patients with staghorn renal calculi. They reported an 87% stone-free rate and 45% needing blood transfusion after a single-session procedure. In their study, major complications, including pneumonia, ileus, deep venous thrombosis, and hydrothorax was 7%. With this technique, the chest complication rate decreases. The risk of penetrating the neck of the calices is higher and may lead to bleeding.

Conclusion

The success of PCNL in patients with staghorn calculi is highly dependent on the optimal access into the targeted kidney. The multiple-access tracts that result in higher success rates can be used with a slight increase in the incidence of acceptable complications. The impact of PCNL using single or multiple-access tracts on renal function is similar and of a temporary nature. Our results also indicate that a history of previous open renal surgery is the only predictive factor for multiple-tracts surgery.

Disclosure Statement

No competing financial interests exist.

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Abbreviations Used

AUA = American Urological Association
BMI = body mass index
CT = computed tomography
Hb = hemoglobin
Hct = hematocrit
IVU = intravenous urography
PCNL = percutaneous nephrolithotomy
SWL = shockwave lithotripsy