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Original Research Article

Is single tract puncture feasible in percutaneous nephrolithotomy for staghorn calculus: our experience from a tertiary care centre

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ABSTRACT

Introduction: Staghorn calculi are branching stones that usually fill the renal pelvis and branch into a few or all the calices. However, complex caliceal and staghorn stones are difficult to remove with a single-tract PCNL approach. A trend toward the use of percutaneous monotherapy using multiple tracts as the preferred treatment option for most staghorn or complex calculi has emerged.
Methods: The single center observational study was carried out on 51 adult patients having staghorn stone from January 2020 to June 2022 at KMC Manipal. Imaging was done to assess the size of the stones, the anatomical features of the kidney and its function, and to accurately plan the operative approach. PCNL was performed in the prone-position; Postoperatively, patients were monitored determining the efficacy of PCNL, perioperative blood loss, the duration of the operative procedure and hospital stay, and the resulting complications.
Results: 42 Single tracts (82.35%), 09 Multiple tracts (17.64%) PCNL was performed. Stone burden=complete staghorn, 33 (64.70%), Partial staghorn 18 (35.30%). Mean age was 48.65 years. Mean length of stones, 25.28 mm. Number of stone, Single-31 (60.78%), Multiple-20 (39.22%). Mean procedure time 117.28±9.12. 9 patients had bleeding requiring blood transfusion and one patient requiring angioembolization.
Conclusion: PCNL is effective and safe in management of staghorn renal stones.

Keywords: Percutaneous nephrolithomy, Staghorn stones, Urinary tract infections, Urolithiasis

INTRODUCTION

Staghorn calculi are branching stones that dominate the collecting system. They usually fill the renal pelvis and branch into at least one calyx. Most of times they are composed of struvite (magnesium ammonium phosphate), which are linked to recurrent urinary tract infections by urease-producing pathogens. Staghorn or complex caliceal calculi constitute one of the most challenging problems in urology and are likely to destroy the function of the kidney and cause life threatening sepsis .[1] The phrase "partial staghorn" calculus refers to a branched stone that occupies a portion but not the entirety of the collecting system, and "complete staghorn" calculus refers to a stone that occupies nearly the entire collecting system.[2]

A trend toward the use of percutaneous monotherapy using multiple tracts as the preferred treatment option for most staghorn or complex calculi has emerged.[3]

However, a concern with creating multiple percutaneous tracts is the potential risks of bleeding and higher complication rates compared with the single-tract approach.[4] Open stone surgery is used less commonly due to its invasiveness and availability of less invasive procedures. Nowadays, PCNL is the first choice in the treatment of stones >2 cm, as well as complicated renal stones like staghorn stones, multiple stones, and stones associated with abnormal renal anatomy.

To study efficacy of single tract puncture in stone clearance rate in PCNL for staghorn calculi. To assess on the effectiveness and safety of single- versus multiple-tract percutaneous nephrolithotomy in the surgical management of complex caliceal calculi or staghorn stones.

METHODS

Study type

It was a prospective observational single centre study.

Study place

The study was conducted in Kasturba Medical College, Manipal.

Study duration

The duration of the study was from January 2020 to June 2022.

Sample size

51 patients were taken for the study. The patients were included in the study based on following inclusion and exclusion criteria.

Inclusion criteria

All adult patients who present with staghorn calculi are eligible for study.

Exclusion criteria

Exclusion criteria were age of a patient under 18 years and over 80 years, stones <15 mm, ASA index above III, presence of cardiovascular or pulmonary insufficiency, renal insufficiency, untreated urinary tract infection, renal abscess, congenital anomalies, including obstruction of the ureteropelvic junction or ureterovesical junction, presence of uncorrected coagulopathies, bilateral upper urinary tract obstruction, pregnant women, and radiolucent stones.

An informed written consent was obtained from the patients. Pre-operative preparation of patients includes medical history, complete blood count (hemoglobin, serum urea, creatinine, sodium, potassium, uric acid, albumin, protein, PTH, and vitamin D3), urine sediment, tests for hemostasis and blood group, urine culture, electrocardiogram (12 lead), 2D echo (If required) and chest X-ray, and consultation with an anesthesiologist. The degree of anesthesia risk was determined by the scale of the American society of anesthesiologists (ASA).[5] Before each intervention, an X-ray KUB and computerized tomography urography was performed to assess the size of the stones, the anatomical features of the kidney and its function, and to accurately plan the operative approach. The size of the stone was calculated based on the widest diameter of the CT urography series, and hounsfield unit (HU) was measured for radiographic assessment of the stone density.

Patients with a bacterial infection detected by urine culture were treated with antibiotic therapy and operated on after receiving a sterile urine culture. PCNL, antibiotic prophylaxis with Inj. ceftriaxone 1 g was prescribed preoperatively in all patients. The procedure began in the position of dorsal lithotomy before the main lithotripsy procedure, with a retrograde application of an open 5 Fr ureteral catheter that allowed the injection of contrast material to opacify and distend the collection system. It was fixed for 14 Fr foley catheter. Next, the patient was repositioned and placed in a prone position on the operating table compatible with the C-arm. The radiation source was placed under the patient to minimize radiation exposure to the surgeon and medical staff. After opacification of the collection system by injection of contrast material through the ureteral catheter, puncture of the pyelocaliceal system was performed using an 18-gauge puncture needle under fluoroscopic control.

The most common puncture site was the upper calyx. Puncture of calyx by bull's eye technique. The position of the tip of the needle was checked by rotating the "C-arm" to 0° and 30°. When it was established that the needle was in the calyx, the stylet was removed, and the exact position of the needle was confirmed by urine and contrast aspiration. Next through the puncture needle was placed 0.035 working guidewire. The guidewire was placed under fluoroscopic control. Once the guidewire was well-positioned, the puncture needle was removed, and a 1 cm incision was made at the site of the wire. Next, the tract was extended through a guidewire with metal telescopic Alken dilators to 24-30 Fr.

Through the last dilator, we introduced the amplatz sheath and through it, we placed the nephroscope. In cases of complicated stones or difficulty in maintaining the percutaneous pathway, we used a second, safety guidewire as an adjunct to the initial working wire. Its purpose was to maintain access to the kidney if the working wire was bent or displaced. This safety wire was stored until the end of the whole surgical procedure.

After placing the nephroscope, the lithotripsy was performed with a dual, pneumatic and ultrasonic intracorporeal lithotripter, swiss litho clast master, using the wolf 26 Fr nephroscope and fragments extracted through the nephoscope using forceps and mechanical suction. In some cases, the dilatation of secondary tracts was done according to the shape of the stone.

Confirmation of stone-free status virtually and under fluoroscopy. Ureteric catheter left as a stent when the session was finished, but if indicated a ureteric catheter is replaced with a DJ stent inserted in an antegrade fashion. 22 French nephrostomy tube was placed in the main track while 20 French nephrostomy tubes were placed in any further tracts and all the tubes were closed till the next morning. Intraoperative procedure time, the number of access tracts, access calyces, need for blood transfusion and any intraoperative complications were recorded.

Operative time was defined as the time from the introduction of the needle into the skin of the patient to the placement of the nephrostomy tube. Stone was sent for analysis. Post-operative assessment, the patients were allowed to resume oral feeding 4 hours postoperatively. The closed nephrostomy tube was opened 24 hours postoperatively. 1st post-operative day, complete blood count, X-ray KUB was done. Nephrostomy tubes were removed routinely after confirmation of a stone-free state. The urethral catheter was removed on the second day postoperatively.

DJ stent was removed after 1 month postoperatively. In patients with residual stones that needed second look PCNL, Ureteric catheter and nephrostomy tube were left till the second look which was done 2-3 days later. The postoperative Hemoglobin level was evaluated. The length of hospital stays, postoperative transfusion, and any early or late complications was recorded. We defined the success of the treatment by determining the stone free rate-SFR, the need for additional procedures, the degree of complications after treatment, the degree of blood loss by determining the difference between pre-operative and post-operative values of hemoglobin and hematocrit, and the duration of the procedure and time. The effectiveness of the method was assessed by determining the absence of clinically significant residual fragments >4mm in the postoperative period without the presence of diagnostic criteria for sepsis.

Intraoperative and post-operative complications were classified based on the modified Clavien-dindo scale. Residual stones >4 mm was treated with ESWL and ureteral stones migrated to the lower urinary tract by ureterorenoscopy. The hospital stay was calculated from the day of the operation until the day of discharge. Follow-up at 1 month by X ray KUB/USG KUB/NCCT KUB.

Ethical approval

Issued by Institutional Ethics Committee KMC Manipal.

Statistical analysis

The statistical analysis was performed with SPSS v.19.0 (SPSS Corporation, USA). Fisher's exact test and Chi-square test were used to compare categorical variables and Student's t-test to compare metric variables. The value of $p<0.05$ was considered statistically significant.

RESULTS

A total of 51 patients underwent PCNL, preoperative patients' characteristics are summarized in Table 1.

Table 1: Pre-operative characteristics of patients.

Variables	Number	Percentage
Mean age	48.65 years	19-78 (S.D.)
Gender		
Male	31	60.78
Female	20	39.22
Stone side		
Right kidney	29	56.86
Left kidney	22	43.14
Stone burden		
Complete staghorn	33	64.70
Partial staghorn	18	35.30
Stone number		
Single	31	60.78
Multiple	20	39.22
Solitary kidney		
Contralateral nephrectomy	4	7.84
Contralateral kidney dysfunction	2	3.92
Mean BMI (kg/m^2±S.D)	25.11	±3.92
Previous procedure		

Continued.

Variables	Number	Percentage
Pyelolithotomy	2	3.92
ESWL	6	11.76
DJ stent	4	7.84
Mean pre-op S. creatinine (mg/dl±S.D.)	1.2	±0.4
Pre-operative serum Hg (g/dl±S.D.)	13.94	±1.00
Pre-operative serum HCT (%±S.D.)	42.49	±2.52
Pre-operative anesthetic risk by ASA		
ASA class 1	11	21.56
ASA class 2	32	62.74
ASA class 3	8	15.70
Stone characteristics		
Mean length of stones (mm±S.D)	25.28	±5.58
Mean width of stones (mm±S.D)	18.21	±2.80
Mean surface area of stones (mm^2±SD).	371.24	±131.86
Solitary staghorn stone	46	90.19
Multiple stones	5	9.80
Number of tracts		
Single tracts	42	82.35
Multiple tracts	09	17.64
Mean density of stones (HU±S.D.)	949.78	±207.28
Mean procedure time (minutes)	117.28	±9.12
Puncture		
Superior calyx	24	47
Middle calyx	04	7.84
Inferior calyx	23	45.09
Localization of the stones (n/%)		
Renal pelvis	21	41.17
Upper calyces	4	7.84
Middle calyces	4	7.84

In our study, the initial SFR for the multiple tract PCNL was 84 %, while the SFR for single tract PCNL was 96%.

Table 2: Number of tracts and stone free rates.

Number of tracts	Stone free rate (%)
Single-42 (82.35%)	96
Multiple-09 (17.64%)	84

Table 3: Comorbidities.

Comorbidities	N (%)
None	27 (52.94)
Hypertension (HT)	11 (21.56)
Diabetes mellitus (DM)	09 (17.64)
Bronchial asthma	01 (1.9)
Ischaemic heart disease (IHD)	03 (5.88)

The most common comorbidities in our patients were Hypertension followed by diabetes and IHD. The average reduction in hemoglobin level was 1.6 g/dl, nine (17.64%) patients had bleeding requiring blood transfusion and 1 (1.96%) patient required angioembolization and urosepsis was noted in 2 patients.

Table 4: Complications.

Complications	N (%)
Mean drop in Hb g/dl	1.6
Bleeding requiring blood transfusion	9 (17.64)
Bleeding requiring angioembolization	1 (1.96)
Hydrothorax	1 (1.96)
Pneumothorax	1 (1.96)
Urosepsis	2 (3.92)

Table 5: Chemical composition.

Composition	N (%)
Calcium oxalate (CaOx) monohydrate	22 (43.13)
Calcium oxalate dihydrate	14 (27.45)
Struvite	9 (17.64)
Brushite	1 (1.96)
Cystine	5 (9.80)

The most common type of stone composition was CaOx monohydrate followed by CaOx dihydate followed by struvite stones and least common composition was brushite stone.

DISCUSSION

The goal of surgical therapy for renal stones is to achieve maximum stone clearance with the least morbidity to the patient.6 In the age of modern medicine, thanks to the development of small caliber nephoscope as well as various types of intracorporeal lithotripters, treatment options for renal stones have changed dramatically and the indicative area of PCNL has expanded.[7] Today, PCNL is not only the first choice in the treatment of stones >2 cm, as well as in complicated renal stones (staghorn stones, multiple stones, and stones associated with abnormal renal anatomy).[8] And is also a method for optimal treatment of medium-sized stones that are not treated with other less invasive methods.[9] Nevertheless, PCNL considered a demanding procedure and it is only safe and effective in experienced hands.[10]

ESWL, retrograde intrarenal surgery, and percutaneous nephrolithotomy (PCNL) are recommended as methods of choice in the treatment of renal stones between 10 and 20 mm. Which minimally invasive technique will be chosen depends on several factors affecting the treatment of renal stones, which can be grouped into four categories.[11]

Factors related to stones

Localization, size, number, and chemical composition.

Anatomical factors of the kidney

Obstruction or stasis, hydronephrosis, stenosis of the ureteropelvic junction, calyx diverticula, horseshoe kidney, renal ectopia or fusion, and lower pole stones.

Clinical factors

Infections, obesity, body deformities, coagulopathies, hypertension, and renal failure.

Technical factors

Availability of modern treatment instruments, operator experience, patient requirements, physician preferences, method success rate, treatment complications, and cost .[12] It is known that PCNL for the treatment of staghorn stones is a challenging procedure. It requires considerable experience in gaining percutaneous tracts, performing delicate and judicious intrarenal manipulations, mastering all techniques of intracorporeal stone disintegration, and weighing the benefits of complete stone clearance against the risks of complications.[13]

Conventionally, in PCNL the patient is in a prone position. Prone position provides a larger area for puncture selection, including a puncture of the upper calyx, wider space for manipulation with the nephroscope and lithotripter, and a lower risk of perirenal visceral injury.[14] However, there are drawbacks to performing PCNL in the traditional prone position such as patient discomfort, relatively long intervention time due to patient repositioning, anaesthetic risks including circulatory problems, respiratory difficulties, suboptimal airway control, increased sympathetic activity, and possible lesions of the cervical spine or peripheral nerves.[15] In our study, all procedures were performed in a prone position; percutaneous renal access was performed by a urologist under fluoroscopic control. In 24 (47%) patients, renal access was performed by upper calyx in 04 (7.84%) patient through the middle calyx in 23 (45.09%) patients through the lower calyx. The choice of approach depended on the location of the stones.

The mean operative time in our study was 90 minutes, which is longer than in other studies (Shalaby et al, 80 minutes).[16] This could be attributed to the difference in experience, facilities and completeness of stone clearance. The ideal tract is the one that provides the shortest and simplest access to all stones. Renal access to the upper calyx, which is most commonly performed in the 11th and 12th intercostal spaces, is associated with multiple complications due to the proximity of the upper calyx to the lungs. Therefore, pneumothorax, pleural effusion, and calico-pleural fistulas are more commonly seen with access to the upper calyx, and pulmonary complications have been reported in almost a quarter of patients undergoing intercostal access.[17] In three patients in our study was the approach supracostal, with one patient developing pneumothorax and other patient developing hydrothorax which required chest tube placement in both patients.

A study by Kukreja et al compared the Amplatz dilators, Alken coaxial metal dilators, and balloon dilators.[18] There was less blood loss with the use of the Amplatz dilators, but without a statistically significant difference between them. In our series, the Alken metal dilators were used and our results in terms of blood loss and safety did not differ from the results of Kukreja's study using metal coaxial dilators. The average operating time in our study was 117.28±9.12 min, which is similar to the time reported by Kurtulus et al (2.2 hours).[19] The longer operating time in our study can be explained by the fact that our procedures was performed by surgeons with an initial level of experience and residents as it's a teaching institute with residency program. We calculated the time interval from the initial placement of the ureteral catheter to the fixation of the nephrostomy tube.

It should also be noted that we performed subsequent dilatation when establishing the intrarenal route with metal dilators. In our study, the effectiveness of the method was assessed by determining the absence of residual fragments from the stones (SFR), or the presence of clinically insignificant fragments≤4 mm in diameter relative to the initial size of the stones, at the end of the one month, at which the success rate of 92% for PCNL was achieved. In the Giusti and Shoma studies, the overall SFR was 95.4 and 92%, respectively.[20,21] In our study, the initial SFR for the 1st post operative day was 84.57%, while the overall success rate for the 30th post-operative day was 91.85%. This result is consistent with Shoma's result. The treatment of residual fragments depended on the location and their size. URS was performed in 3 (5.88%) patients and ESWL in 6 (11.76%) patients with total rates of additional procedures of 9 (17.64%). These results are consistent with the results in the literature. The overall incidence of complications after PCNL is small. Bleeding is the most significant complication of PCNL, with transfusion rates ranging from 1% to 10%. Bleeding from an arteriovenous fistula or pseudoaneurysm requires immediate embolization and occurs in less than 0.5% of patients. Acute haemorrhage is usually venous in nature, and in most cases, the clamping of the placed nephrostomy tube is sufficient to control it. In PCNL, absorption of the irrigation medium may occur, which is why it is necessary to use saline as a means of irrigation. The most common complications of PCNL are fever, bleeding, and prolonged leakage of urine through the renal approach.[22] In the study of Tefekli et al the total incidence of complications graded according to the Clavien-Dindo scale with grades 3–5 was 10.5%, while for grades 1 and 2, the total complication rate was 20.3%.[23]

In our study, 4(7.84%) cases had a complication of Grade 3-5 on the Clavien-Dindo scale. Prolonged haematuria but without the need for transfusion was observed in 3 (5.88%) patient (Clavien-Dindo II). While, elevated post-operative temperature was observed in 6 (11.76%) patients (Clavien-Dindo I) .The temperature was higher than 38.7°C, and it was treated with antibiotics and antipyretics. No significant intraoperative complications were observed in this study. Intraoperative bleeding occurred in 4 (7.84%) patients. The bleeding was minor and originated in the accessory tract, requiring neither blood transfusion nor embolization. The patient nephrostomy tube (Malecot 24 Fr) was clamped in a period of 1 hour for tamponade and stopping the haemorrhage. The smaller rate of complications in our study is probably due to a proper patient selection, safe and single tract access and intraoperative care to minimize bleeding.

The majority of patients had a stone in the renal pelvis with calculus extending into upper, middle or lower calyx with consequent hydronephrosis, and the lower calyx was most commonly punctured. Staghorn calculus as part of Recurrent lithiasis was seen in 5 patients (9.80%). We used the difference between pre-operative and post-operative haemoglobin levels as an indicator of blood loss, the average reduction in haemoglobin level was 1.6 g/dl, which was higher than the results of a study by Shaban et al. Where the fall in haemoglobin was 0.79 g/dl.[24] Nine (17.64%) patients had bleeding requiring blood transfusion and 1(1.96%) patient required angioembolization. In the current study, the mean length of hospital stay was (3.57±1.23 days) which is lower than the study by Giusti et al, where the mean hospitalization at standard PCNL is 5.3 days.[21]

Limitations of the study was that the small number of patients is the main limiting factor in this study. This study could not compare stone free rates based on location of puncture of calyces.

CONCLUSION

PCNL is safe and effective in management of Complex Staghorn calculus. Currently single tract PCNL can achieve maximum stone clearance with better stone-free rates and with less complications than Multiple tract PCNL. It is known that PCNL for the treatment of staghorn stones is a challenging procedure. It requires considerable experience in gaining percutaneous tracts, performing delicate and judicious intrarenal manipulations, mastering all techniques of intracorporeal stone disintegration, and weighing the benefits of complete stone clearance against the risks of complications.

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