International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 13, No. 6, June 2024 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.6.2024.58

ORIGINAL RESEARCH

Safety and Efficacy of Supracoastal Access for PCNL: A Tertiary Care Centre Experience

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Received date: 16 May, 2024 Acceptance date: 10 June, 2024

ABSTRACT

Background: The supracostal route for percutaneous nephrolithotomy (PCNL) is often underutilized due to concerns about safety and potential thoracic complications. This study was aimed to evaluate the safety and efficacy of supracostal puncture for PCNL procedure. **Methodology:** This is a prospective observational study conducted in the Department of Urology, GGH Kurnool, Andhra Pradesh, India, from January 2020 to December 2022. All supracostal punctures were performed above the 12th and 11th rib spaces by urologists, guided by a c-arm, with the patient in the prone position. The mean operative time, stone-free rate, mean hospital stay, and complications were evaluated. Data was presented as frequency (%). **Results:** A total of 150 patients underwent PCNL, of whom 39 patients had supracostal access Single supracostal tract access was used in 39(89.7%) cases, and 4(10.3%) patients required a second infracostal tract. Overall 84.6% of the patients were rendered stone free or had clinically insignificant residual calculi with PCNL alone and this increased to 100% with ancillary procedures. In patients with multiple calculi, they were completely cleared in 50% of patients with PCNL and 100% with ancillary procedures. The overall complication rate was 10.2% which included Bleeding in 4 patients out of which two patients required transfusion and pneumothorax in 1 patient(2.5%) which was managed with intercostal chest drain. No haemothorax, hydrothorax, or bowel injury developed. Mean post-operative stay was 3.5 days. **Conclusion:** Supracostal puncture is a safe and effective method which gives a high stone free rates with acceptable and easily manageable complications.

Key-words: Supracostal access, Renal calculi, Infracostal tract, Percutaneous nephrolithotomy

INTRODUCTION

Renal calculi, commonly known as kidney stones, represent a prevalent and distressing ailment that contributes significantly to health-related issues and financial burdens within society. Apart from causing recurring pain, this condition also poses a risk for bone fractures, cardiovascular ailments, and chronic kidney disease.[1] Percutaneous nephrolithotomy (PCNL) is the favoured option for managing kidney stones, and it has undergone significant advancements since its initial introduction in the 1980s.[2]The AUA Nephrolithiasis Clinical Guidelines panel recommended percutaneous stone removal as the first treatment option for managing staghorn calculi patients.[3]

The success of PCNL relies on the accurate percutaneous entry and reaching the correct calyx. The achievement of the surgery and subsequent effective stone clearance are closely connected to the chosen approach. For upper calyx stones, utilizing the supra-costal access is more advantageous due to the upper pole's relatively posterior and medial position in comparison to the lower pole.[4] The upper calyceal approach is considered ideal for approaching the renal PCS when managing staghorn stones, complex upper and lower calyceal calculi, proximal ureteric calculi, and calculi associated with primary pelvic–ureteric junction obstruction.[5-7] With this approach access to the lower calyx, renal pelvis, and upper ureter can be easily achieved if the initial puncture is appropriate.[8]

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However, many urologists hesitate to use a supracostal approach because of the potential for intrathoracic complications .

This study aims to evaluate the safety and efficacy of supracostal puncture for PCNL procedure.

MATERIALS AND METHODS

Study design

This prospective, observational study was conducted at the Department of Urology, GGH Kurnool, Andhra Pradesh, India, between January 2020 and December 2022.

The study was approved by institutional ethics committee and was performed in accordance with the Declaration of Helsinki and the International Conference on Harmonization guidelines. Written informed consent was obtained from all the participants prior to enrolment in this study.

Study participants

Patients with diagnosis of renal calculi and those who were selected to undergo under PCNL were enrolled in this study.

Data collection

Data was collected for all the patients who fulfilled eligibility criteria. Demographic and baseline data was recorded along with pre-operative laboratory investigations such as CBC, RFT, coagulation profile, and negative urine culture. Radiological evaluation was done by X-Ray (kidney, ureter, and bladder) KUB, USG KUB, and CT KUB.

Study treatment procedure

Patients with pre-operative positive urine culture received antibiotics for 1 week pre-operatively. The decision to perform supracostal puncture was based on the stone location, the configuration of the pelvi-calyceal system, and the likelihood of maximal stone clearance. All procedures were performed in a single stage. After induction of GA, the patient was placed in a lithotomy position, the ureteral catheter was placed into the renal pelvis. The patient was then turned to a prone position, and RGP was done to select the appropriate calyx. Patients with large stone burden in the upper calyx and renal pelvis were selected for upper calyceal puncture. The puncture was done above the 12^{th}or 11th rib in 39 patients, and it was done through the lateral half of the intercostal space breath holding in full expiration and the needle was advanced through the upper border of the lower rib in an intercoastal space to avoid the intercostal vessel injury. Once the collecting system was entered, a guidewire was passed into the ureter. At this stage for some patients, a second guidewire was used to pass through a separate puncture for a stone in the other calyx to be used later for the creation of a second access tract for complete clearance of the stone. Subsequently, the access tract was dilated with fascial dilators up to 22Fr or 24Fr and finally a 22Fr or 24Fr Amplatz sheath was placed. The stones were extracted by an alligator grasper or fragmented by a standard pneumatic lithoclast before extraction by a grasper. After stone removal, careful inspection of the accessible calyces, the renal pelvis, and the Ureteropelvic junction (UPJ) was performed to exclude the presence of residual stones, injury, and oedema of the UPJ. Stone clearance was confirmed finally on C-Arm. A 14Fr or 16 Fr Foley catheter was placed through the Percutaneous nephrostomy (PCN) tract to tamponade the bleeding and a 5Fr DJ stent was placed in antegrade fashion. On suspicion of any chest complication, intra-operative X ray was done with C-Arm, a thoracic surgeon was consulted and intercostal chest tube drainage was done if indicated. All patients were examined at the end of the procedure for equal air entry into both sides of the chest, and adequate oxygen saturation was confirmed. In the immediate postoperative period, the patients were observed for signs of bleeding by recording the vital signs and observing the urine output for gross haematuria. Pre and post-operative Hb level was measured, and any drop was recorded. Stone clearance was assessed by USG KUB and CT KUB 1 month after surgery.

RESULTS

A total of 150 patients were enrolled for PCNL out of which 39 patients were selected for supracostal approach. Out of 39 patient's majority of were male [n=26 (66.6%)] and 13 (33.4%) were female.

The mean haemoglobin of the patients was 11.2 gm/dL. Comorbidities were reported among 20 patients, 10 patients had history of diabetes mellitus whereas 10 patients were hypertensive. Nine patients had past history of renal calculi. On assessment of size of renal calculi, majority 24 (61.5%) of the patients had <2 cm calculi; 12 (30.7%) patients had >2 cm calculi and staghorn stones were reported in 3 (7.6%) patients. **[Table1]**

Single tract access was used in 35 (89.7%) patients. The additional infracostal tract was required in 4(10.3%) patients. Overall 84.6% of the patients were rendered stone free or had clinically insignificant residual calculi with PCNL alone and this increases to 100% with ancillary procedures.

On the basis of stone sizes, full success was achieved in 22, 11 and 2 patients with the stone size <2 cm, > 2cm and staghorn stone respectively. **[Table2]**

The overall complication rate was 12.7%. The complications comprised of bleeding and haematuria in 4 patients (10.2%) and pneumothorax in 1 patient (2.5%) which required insertion of chest tube. Fall in Hb levels was reported in 4 patients, out of which blood transfusion was required in 2 patients.**[Table3]**

The mean duration of surgery was 82 minutes which ranged from 45 to 120 minutes depending on size and complexity of the stone. The rest of the patients recovered successfully. Post-operative stay ranged from 2 to 5 days with mean stay of 3.5 days.

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Table 1: Demographic and baseline characteristics of patients

Patient characteristics	N=39
Sex	
Male	26 (66.6)
Female	13 (33.3)
Hb, mean	11.2
Comorbidities	20 (51.2)
DM	10 (25.6)
HTN	10 (25.6)
History of renal calculi	9 (23.1)
Size of renal calculi	
<2 cm	24 (61.5)
>2 cm	12 (30.7)
Staghorn stones	3 (7.6)
Data presented as n (%), unless otherwise specified. Hb, hemoglobin; DM, diabetes mellitus; HTN, hypertension.	

Table 2: Success rate of PCNL on the basis of stone sizes

Success rate	Full success	Partial success	Total
Stone size	N (%)	N (%)	N (%)
<2 cm	22 (91.6)	2 (8.3)	24 (100)
>2 cm	11 (91.6)	1 (16.6)	12 (100)
Staghorn stones	2 (66.6)	1 (33.3)	3 (100)

Table 3: Frequency of complications occurred during supracostal access

Complications	Number of patients (N=39)
Bleeding and haematuria	4 (10.2)
Patients who required transfusion	2 (5.1)
Pneumothorax	1(2.5)
Haemothorax	0
Hydrothorax	0
Data presented as n (%).	

DISCUSSION

Percutaneous nephrolithotomy is a vital technique for treating larger kidney stones, often used alone or alongside extracorporeal shock wave lithotripsy. It has replaced open surgery for bigger kidney or upper ureteral stones due to its minimally invasive nature. The present study findings highlights on the safety and efficacy of the supracostal approach for PCNL. The safety profile was studied in terms of mean hospital stay, intrathoracic complications, organ injury, need for blood transfusion, stone clearance rate. The most important step in the PCNL procedure is tract formation, the ideal tract is the one in which the infundibulum is short, wide, and straight so that the surgeon can easily manipulate the nephroscope and other instruments for stone clearance.[9,10]In the beginning days of PCNL most urologists hesitate for doing PCNL through the supracostal route so the majority of urologists used a subcostal approach which mostly leads to a large bulk of residual stones as stones were not properly approached and bleeding due to extra torque applied over nephroscope in the kidney.[11]Nowadays supracostal PCNL is considered as safe as subcostal in terms of hydrothorax, bleeding, perinephric fluid collection, injury to adjacent viscera, and stone clearance.[12]

The majority of the patients were male in the present study (66.6%) which was similar to another study by Ahmed M et al.[13](65% males). In this study, renal stones located in the upper calyx, lower calyx, kidney pelvis, and proximal ureter using an 18Fr semi-rigid nephroscope. Based on pre-operative CT scans and intra-operative retrograde contrast studies of the pelvic-collecting system, the surgeon chose to utilize a supracostal approach for PCS access. In 4 cases, an additional second puncture was employed to access the PCS due to significant stone size and complex PCS anatomy. This dual puncture technique improved stone clearance, resulting in an overall stone clearance rate of 84.6% through PCNL alone, which further increased to 100% when combined with supplementary procedures like ESWL, Ureteroscopy, and RIRS. Similarly, in a retrospective study conducted by Lange et al. among the 642 patients, 127 underwent kidney access through the supracostal route, while 515 opted for the subcostal approach. The group that underwent supracostal PCNL achieved 88.3% rate of stone clearance, accompanied by an 11% complication rate. Based on these outcomes, the

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study's conclusion stated that supracostal PCNL offers a secure and successful method for managing kidney stone patients of different stone sizes.[14] A study by Elsayed Marei et al aimed to compare the safety, operative time, and effectiveness of supracostal puncture versus subcostal puncture in PCNL. The supracostal group exhibited a success rate of 72%, with 8.0% requiring a second-look PNL, 4.0% needing both a second-look PNL and ESWL, and 16.0% necessitating ESWL. In contrast, the subcostal group had a success rate of 64%.[15]

The overall rate of complications in the present study was 12.7% which consists of bleeding and haematuria in 4 patients, and pneumothorax in one patient andTwo patients (5.1%) necessitated blood transfusion due to bleeding. In a study conducted by Sukumar S. et al. a notable occurrence of significant bleeding requiring blood product replacement was observed in 1.8% of cases.[16]In a retrospective study by E. Radecka et al. blood transfusion was required due to bleeding in 5 (6%) of patients which was comparable to the present study.[17] No incidence of hydrothorax or haemothorax occurred during procedure. One patient required chest tube insertion due to pneumothorax. A study by Kunwar A. et al reported 1 case of hydrothorax and 2 cases of minimal pneumothoracic complications. [18] Another study on thoracic complications of supracostal approach of PCNL reported 5 (29.4%) cases of pneumothorax.[19]

The mean duration of surgery was 82 minutes ranged from 45 to 120 minutes, which was significantly higher than the mean procedure time reported by S. Rafi et al in their study which was 46.13 minutes.[4]Another study has reported mean duration of surgery as 48.4 minutes.[20]A study by Ahmed M. et al. observed the mean procedural time as 77.4minutes ranging between 40–115 minutes. These findings were comparable to the present study.[13]The mean hospital stay was 3.5 days ranging from 2 to 5 days. Comparable findings were reported by Hossain M et al. The average postoperative hospital stay was 5.5 days, with a range of 2 to 9 days.[21]Also, Meng-Yi Yan et al.[22] has reported mean length of hospital stay was 4 days in their study which was comparable to the present study.

Supracostal puncture is more successful than subcostal puncture for treating staghorn renal calculi, despite potential chest-related concerns. Conservative management is often sufficient for supracostal cases, which carry comparable risks to subcostal punctures but yield better stone clearance results. Following essential PCNL principles during puncture and perioperative monitoring can reduce supracostal puncture complications. Proper percutaneous renal access is crucial in PCNL, and for the supracostal approach, correct Amplatz sheath positioning is vital. Puncture should occur during breath-holding in a fully exhaled state, avoiding the lower rib margin to prevent intercostal vessel damage, and maintaining placement within the lateral half of the intercostal space.

CONCLUSION

The present study concludes that supracostal PCNL is a safe and effective procedure for treating kidney stones if a urologist has a good understanding of the anatomy surrounding the upper pole of the kidney and attention to a few technical considerations during the procedure upper calyceal approach can be performed safely and effectively.

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