Original Article

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Thoracic Complications in Supracostal Percutaneous Nephrolithotomy

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ABSTRACT

Background: Due to the risk of pleural injury leading to thoracic complications, many urologist still hesitate to perform supracostal puncture during percutaneous nephrolithotomy. Our aim of this study was to evaluate the thoracic complications in supracostal access percutaneous nephrolithotomy.

Methods: This is a retrospective analysis of 101 patients who were treated with supracostal access percutaneous nephrolithotomy at our institute from September 2013 and December 2019. Indications for supracostal punctures were staghorn 28(27.7%), middle calyceal stones 10(9.9%), pelvic stones 29(28.7%), complex inferior calyceal stones 26(25.7%), upper calyceal stone 10(9.9%)and upper ureteric stone17(16.8%).The intercostal space between the 11th and 12th ribs was used in all the cases.

Results: Among the 101 patients who undergone percutaneous nephrolithotomy by supracostal access, three patients (2.97%) had pleural injury. Among them one patient developed hydrothorax and needed chest tube insertion and remaining two patients had minimal pneumo thorax with blunting of costo-phrenic angle, which was managed conservatively. The lung parenchymal or other viscera injury was not observed in our study. Most punctures were, a single supracostal superior calyceal access 18(17.8%) and middle posterior calyceal access 88(82.2%), except for staghorn and multiple complex lower calyceal calculi needed multiple tracts 23(22.8%). Complete clearance was observed in 77(76.2%) patients.

Conclusions: The supracostal puncture was a safe and effective approach with high stone clearance rate and acceptable morbidity in selected cases of staghorn, upper ureteral, and upper calyceal calculi. It should be adapted whenever needed and should not be avoided due to fear of chest complications.

Keywords: Percutaneous nephrolithotomy; pleural injury; stone clearance; supracostal puncture

INTRODUCTION

In the era of modern endourology ,PCNL is well established mode of treatment for renal stones including staghorn, complex calyceal and upper ureteric stones. An ideal puncture provides short and straight access to all the calculi, avoid major vessels; bowel and lung, lies along the axis of the calyx and causes minimal parenchymal damage with maximum stone clearance.[1,2] The supracostal access allows more maneuverability and less torque on the renal parenchyma.[3] Traditionally, subcostal access is preferred over supracostal access in PCNL to avoid potential complications of pneumothorax, hydrothorax and lung injury.[4-6] Hydrothorax is the most frequently encountered complication and it accounts of 6-32% overall complication of PCNL,[7-10] others studies favors supracostal access for the renal stones in regards to efficacy and clearance of renal stones.[3,11] The aim of our study was to evaluate the overall efficacy and thoracic complications of PCNL performed in our center with supracostal access.

METHODS

We retrospectively analysed the patients who underwent PCNL via supracostal access between September 2013 and December 2019 in our center (Kathmandu model hospital). Data were collected from the hospital database and the study was approved by the ethical committee of institution. Total 101 patients who were undergone surgery through supracostal access were included in this study.

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Multi slice non-contrast Computed Tomography (CT) imaging was done in all patients and contrast study of renal system CT-IVU and DTPA renogram were performed to evaluate the anatomical and functional status of the individual kidney in selected patient. All patients had a pre-operative assessment which included complete blood count, renal function test, coagulation profile, urine routine examination along with urine culture and sensitivity, blood grouping, ECG and chest X-ray. Patients with positive urine culture were treated preoperatively until urine culture becomes negative with susceptible antibiotics prior to surgery.

After administration of general anaesthesia, patients were placed in lithotomy position, ureteric catheter 4,5 Fr in pediatric group and 6 Fr in adult group was inserted via cystoscope into respective pelvicalyceal system. The patients were then placed into prone position, and appropriate structural support with soft padded bolsters were used to obtain the best position for the percutaneous access. All punctures were done under fluoroscopic guidance with help of retrograde pyelogram. All the cases were performed by 2 surgeons by using triangulation technique. The site of puncture were usually 6 to 7 cm away from the midline, between 11th and 12th ribs and immediately above the upper border of the 12th rib, to avoid damage to the intercostal vessels. The needle was introduced between the ribs and through the diaphragm with the patient in full expiration to prevent lung parenchymal injury, whereas entry into the renal parenchyma was made in deep inspiration to provide full downward displacement of the kidney for easy access to the superior or mid posterior calyx in high-lying kidneys. Once the collecting system was entered, a hydrophilic guide wire of size 0.035" was passed and manipulated down the ureter whenever possible. The tract dilations were done by sequential metallic Alken dilators. Amplatz sheath of size 16 to 30 F were used to establish access within the pelvicalyceal system and stones were fragmented using pneumatic lithotripter. The anesthesiology team was preinformed about the possibility of pneumo or hydrothorax in each case. At the end of procedure, DJ stents were placed in all the cases; nephrostomy tube of size 14-18F placed in 22(21.8%) cases who had multiple tracts, persistent bleeding or renal parenchymal laceration. And some were ended tubeless according to the standard and mini perc procedure. In patients suspicious of pleural injury, and lung fields were imaged by using intraoperative C-arm fluoroscopy or ultrasonogram with the patient prone at the end of the surgery. In the cases that showed massive hydrothorax were managed intraoperatively by insertion of a chest tube drain. Formal chest X-Ray was obtained in selected cases if there was decreased air entry on the side of PCNL during auscultation of lungs, or a fall in oxygen saturation or if patient developed dyspnea, tachypnea, or chest pain postoperatively. Chest tube insertion was done postoperatively in patients who had symptomatic hydro-pneumothorax.

RESULTS

Age of the patients ranged from 8-68 years with mean age of 37.5 years. Out of them 65(64.4%) cases were male and 36(35.6%) were female. Among 101 patients in 60(59.4%) patients PCNL were done in right kidney and in 41(40.6%) were done in left kidney. The mean operative time was 92.6 minutes and the mean hospital stay was 5.7days. The locations were high-lying kidneys with staghorn stones 28(27.7%), middle calyceal stones 10(9.9%), renal pelvic stones 29(28.7%), complex inferior calyceal calculi 26(25.7%), stones in the upper calyx 10(9.9%) and upper ureteric stone 17(16.8%) (Table 1).

Table 1. Patient characteristics.

Total no. of patients	101
Male / Female	65/36
Mean age, years	37.5(8-68)
Laterality of the stone, left/ right	60/41
Mean duration of the procedure, mins	92.6
Mean hospital stay, days	5.7
Mean stone size, mm	22.8
Stone location	
Upper ureteric stone	17 (16.8%)
Staghorn stone	28 (27.7%)
Complex lower calyceal stone	26 (25.7%)
Renal pelvis stone	29 (28.7%)
Upper calyceal stone	10 (9.9%)
Middle calyceal stone	10 (9.9%)
Types of procedure	
Standard	68 (67.3%)
Mini	32 (31.7%)
Number of tract	
Single	79(78.2%)
Multiple	22(21.8%)

Single tract access was used in 79(78.2%) cases, whereas 22(21.8%) cases required a second subcostal tract, mainly in staghorn stones and multiple complex calyceal calculi to obtain complete stone clearance. Blood transfusion was needed in 5(4.96%) patients. The indications of blood transfusion were hemoglobin below 9 gm% postoperatively.

Total tubeless (without nephrostomy tube, and DJ stent) in 1(0.99%) case, tubeless (without nephrostomy tube but with DJ stent) in 32(31.68%) cases and standard PCNL (both nephrostomy tube and DJ stent) in 68(67.32%) cases. In 4(3.96%) patients with complete staghorn calculi required secondary PCNL. Total 77(76.23%) patients had complete stone clearance in first attempt, however 3(2.9%) patients had complete stone clearance after secondary PCNL. So complete clearance was observed in 80(79.2%) patients. Significant residual fragments were present in 8(7.9%) patients, of which 4(3.96%) patients were on regular follow up with asymptomatic calyceal stone. The remaining 4(3.96%) patients were later rendered stone free with other ancillary procedure like ESWL after 6 weeks. Clinically insignificant stones ≤ 4mm^2 were seen in 13(12.8%)patients which passed out spontaneously in the follow up period.

Regarding chest complications, pleural injury with hydrothorax and pneumothorax was detected in 3(2.9%) patients on postoperative chest X-ray examination. Among them, one (0.99%) patient required chest tube insertion due to massive hydrothorax. Chest tube drain was removed in 4 days. Rest of the 2(1.98%) patients who had PCNL on right side, pleural and lung injury was detected by scape of air through the initial puncture needle, but procedure was completed by changing the puncture site without any difficulty. Both of the patients had developed minimal pneumothorax postoperatively and were managed non-operatively. The follow up X-ray was normal in all the patients (Table 2).

Table 2. Thoracic complications

Thoracic complications	Number
Massive hydrothorax	1(0.99%)
Pleural injury with pneumothorax	2(1.98%)

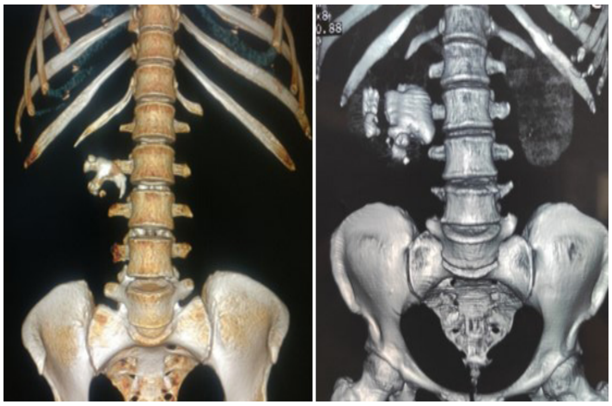

Figure 1. Staghorn stones are best approached through the supracostal puncture.

DISCUSSION

An ideal puncture and optimal access for PCNL are well established fact for the better outcomes of surgery interms of complete stone clearance with minimal morbidity. In the majority of cases of renal calculiwith stones in the renal pelvis, lower calyceal and middle calyceal calculican be easily approached by the puncture through the desired calyx, which ispossible by the traditional subcostal approach. However in staghorn, upper ureteral, and complexupper or lower calyceal calculi, the subcostal approach failsto provide optimal access.[9]

The anatomy of the kidney also favours the superior calyx approach. The lower pole of the kidney is tilted anteriorly because of the slope of the psoas muscle. Access through the superior calyx provides a straight tract along the long axis of the kidney, with excellent visualization of upper and lower calyces, the pelvis and pelviureteric junction.[3] The straight access also provides a favourable environment for easy manipulation of the rigid scopes and forceps with minimum torque on renal parenchyma and hence minimize the bleeding.[12]

Upper ureteric stones are well managed through the supracostal access, however if we attempt the access through the middle and lower calyx, it can lead to angulation between the working sheath and the renal pelvis leading to difficulty in identification and fragmentation of the stone. In our study, the stone clearance of the upper ureteral calculus through the supracostal access was achieved in all 17 patients without any thoracic complications.

The staghorn stones are also best approached through the superior calyx because the most posterior portion of the kidney is the posterior upper-pole calyx, and thus it provides the most direct access to the renal pelvis, upper ureter and lower pole calyces. Most of the time, the posterior interpolar calyx can be accessible without significant angulation.[11] The superior calyx lies above the 12th rib, as on full expiration 80% of right renal upper pole calyces and 85% of left renal upper pole calyces lie above the 12th rib.[13]As most of the staghorn stones including complicated stones are best approached with supracostal puncture. Single supracostal puncture of the upper calyceal and another middle calyceal puncture could clear most of the stone burden in staghorn calculus depending upon the calyceal extention of the branches of staghorn stones and the severity of hydronephrosis. In our study, total of 77(76.23%) patients had complete stone clearance in first attempt and another 3(2.9%) patients had complete stone clearance after secondary

PCNL in same hospital admission. So in total complete stone clearance was seen in 80(79.2%) patients. This result is comparable with those reported by El-Karamany and colleagues[14]78% and Kekre and colleagues[15] 79.5% with supracostal punctures. In our study, single tract access was used in 79(78.2%) cases, however 22(21.8%) cases required a second subcostal tract, mostly in staghorn and multiple complex calyceal stones to obtain complete stone clearance. Shrestha et al.[16] and Adams GW et al.[17] have also reported a 20-40% rate requirement of additional punctures for stones clearance.

The major disadvantage of supracostal access is pleural injury related complications. The complication rate of 35% for punctures above the 11th rib and 10% for those above the 12th rib. Another study conducted by Gupta et al.[3] reported 63 supracostal access procedures, with 14 (22%) sustaining overall complications. Chest complications developed in seven (11%) patients, three with minimal blunting of the costophrenic angle, managed conservatively, while significant hydrothorax and hemothorax occurred in three and one patient, respectively, who were treated with chest drains. Shrestha et al [16] reported the similar thoracic complications in 6 (3.84%) of hydrothorax, out of which only 3 needed chest tube insertion while other 3 were treated conservatively with good recovery. Out of these 4 patients who had supra 11th rib puncture, 3 developed chest complications. Munver and colleague[12]have recommended avoiding a puncture above the 11th rib, to minimise thoracic complications.

In our study, pleural injury with hydrothorax and pneumothorax was detected in 3(2.9%) patients on postoperative chest X-ray examination. Among them, one (0.99%) patient required chest tube insertion due to massive hydrothorax. Whereas in rest of the 2(1.98%) patients had minimal pneumothorax and managed non-operatively. In our centre, we frequently perform supra 12access without any significant thoracic complications, but in current study, all the thoracic complications were detected in the high lying renal units when we asked anesthesiologist for manual inspiration for full downward displacement of the kidney for easy access to the superior posterior calyx. Actually these all the punctures were equivalent to supra 11, even cephalad puncture. Singh et al.[18] have concurred this view point and further emphasized that with due precautions, one should not hesitate to go even for an upper calyceal puncture, if indicated. Yadav R et al.[19], in his study of 762 cases, noted the incidence of hydrothorax to be around 3.3% . However, in our study, the incidence of hydrothorax was only 0.99%.

Meta-analysis conducted by He et al.[20] compared the safety and efficacy of supracostal and infracostal access PCNL. Nine studies were included with total of 2,273 patients. Author concluded that the mean hemoglobin reduction and rate of hydrothorax were significantly increased when using the supracostal approach in comparision to infracostal access. These results indicated that supracostal puncture was effective, but not safe as infracostal access for PCNL. When the puncture is made above the 11th rib the risk of injury to the pleura and the lung is significantly higher; 16 fold greater than with supra 12th rib access[12] and thus access above the 11th rib should be avoided as far as possible.[7,8,10]

To avoid thoracic complications, knowledge of the anatomical relationships of the diaphragm, pleura and lung is very important.[21] During exhalation the lower limit of the posterior parietal pleura crosses the 12th rib obliquely in the vicinity of the lateral border of the erector spinae muscles, such that the lateral portion of the 12th rib is inferior and lateral to the lowest limits of the pleura.[22]Injury to the pleura can be avoided by staying above the lateral half of the 12th rib well lateral to the erector spinae muscle.

Visceral injury related complications were not encountered in the present study. The lung injury and injury to the liver and spleen may occur with the more cephalad puncture, thus we avoided access above the 11th rib.

CONCLUSIONS

Our study has shown that the supracostal approach can be safely performed with acceptable morbidity in PCNL. The higher the puncture, the greater the chance of pleural and lung injury. Although the thoracic complications are higher with supracostal approach than the subcostal approach, however, proper attention to the technique and careful intraoperative and postoperative monitoring can detect thoracic complications, and these can be easily managed without serious morbidity.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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