A Prospective Study of Stone Clearance, Morbidity and Complications of Supracostal Puncture in Percutaneous Nephrolithotomy

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Abstract: *Objective*: Supra-costal access for PCNL is an established modality to enter the collecting system but potential thoracic complications may limit the adequate usage of this accesss. Objective of the study was to identify the factors leading to supra-costal access, the safety and efficacy of this approach and the potential complications.

Materials and Methods: Patients who underwent supra-costal PCNL between December 2014 and March 2017 for the treatment of renal and ureteric stones were prospectively analyzed. We enrolled 51 patients & their data were analyzed for the stone characteristics, clearance & the complications.

Results: A total of 51 patients (10.64%) out of 47 9 patients had a supra-costal access, the puncture was supra 12^{th} in 47 cases(92.15%) and supra 11^{th} in 4 (7.84%) . Second access tract was made in 12 cases for complete stone clearance, 46 renal units (90.19 %) became stone free after the primary and ancillary procedures. Hemorrahge was the most common complication in 7.84 % of cases, inter-costal chest drain had to be inserted in one patient (1.96 %) with supra 11^{th} rib access due to pleural collection. All patients recovered well and were asymptomatic on follow-up.

Conclusions: The supra-costal approach provides optimum access, excellent visualization, reasonable operative times along with comparable blood loss and good stone clearance. Although thoracic complications are slightly higher than with a sub-costal approach, but adequate precautions and methodical approach can minimize their incidence. A post-operative X-ray chest should be done in all cases to detect any thoracic complications.

Keywords: Renal stone, PCNL, Supra-costal Access, Complications, Hydrothorax, Haemothorax, Urolithaisis, Haemorrahage.

INTRODUCTION

PCNL is the procedure of choice for various types of renal calculi [1] and some upper ureteric calculi [2]. The success of percutaneous stone removal depends on an appropriate choice of the renal calyceal approach. An ideal access to the renal calculi should be short, straight and passing through the calyceal axis while avoiding the renal vasculature and causing minimal trauma to the renal parenchyma [3]. Though the potential thoracic morbidity with supracostal access for renal calculi [4-6], makes the supracostal access not a favoured option among the urologists, however, the access offered to the pelvicalyceal system by this route along with high success rates throughout the literature and a low complication rate overrides the reluctance for this access. The present study was done to assess the safety, efficacy of the supracostal route as well as to identify and analyze associated potential complications.

PATIENTS AND METHODS

Between December 2014 and March 2017, four hundred and seventy nine (n= 479) patients underwent PCNL for renal stones out of which 51 underwent supracostal puncture. A detailed medical history was obtained for every patient, and systemic examinations were performed. The preoperative assessment included routine laboratory studies, e.g., blood chemistry, complete blood count, coagulation profile, urine analysis and urine culture.

Renal stone characteristics i.e. location ,size, radiodensity and morphology were preoperatively evaluated using KUB radiographs and intravenous pyelography (IVP) and/or abdominal Computed Tomography (CT).

The decision for supracostal puncture was made on the basis of stone location, possibility of total stone

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clearance, while taking into consideration, the PCS anatomy. The exclusion criteria were complete staghorn calculi, multiple secondary/calyceal calculi, severe co-morbidities, bleeding tendency, ectopic or malrotated kidneys and calculi associated with marked renal deformities.

Antibiotic prophylaxis was routinely administered at the time of anaesthetic induction. All procedures were done under GA as a single stage procedure. With the patient in the lithotomy position, a 6 Fr Ureteric catheter was inserted, subsequently patient was brought in the prone position with proper padding and pelvi-calyceal outline was defined by pushing in the dye, an appropriate calyx which would provide the shortest and straightest path was selected under C-Arm guidance, the PCN needle was pushed through the diaphragm and retroperitoneum in full expiration and was passed through the kidney during deep inspiration with the needle inserted above the upper border of the 12^{th} or the 11^{th} rib , Once the PCS was entered a guide wire was manipulated down the ureter if possible, or coiled in the PCS itself, the track was dilated serially with Amplatz dilators(Cook Urological, Spencer, Indiana, USA) up to 30 F, in cases where a second tract was required, tract dilation was done up to 28 F , and an Amplatz sheath placed. Single-tract access was used whenever possible, an additional tract was used only when needed to facilitate complete clearance. All procedures were performed in a single stage under general anesthesia.

Pneumatic lithotripter was used for stone disintegration and stone fragments were removed, fluoroscopic confirmation after the completion of the procedure was done to rule out the presence of any residual stone or any pleural collection, 'Stone-free' was defined as the complete clearance of stones, 'insignificant residual calculi' were presence of fragments <5 mm, 'significant residual calculi' were ≥ 5 mm after the primary procedure. A 20 Fr nephrostomy tube was placed at the end of the procedure in all patients. Operation time was calculated starting from the puncture for the access, to the insertion of the nephrostomy tube. All patients with a supra-coastal puncture had a chest X-ray on the same day or 1day after surgery to rule out pleural fluid collection or any other thoracic complication.

Post-operatively I.V Tramadol was used for pain relief in all patients, additional doses were administered as per individual subjective requirement.

RESULTS

In a total of 51 cases (10.64%) with supracostal puncture, 63 access tracts were created, the puncture was supra 12^{th} in 47 cases(92.15%) and supra 11^{th} in 4 (7.84%), (Table **1**), in an age range of 18 to 67 years [mean age 42.37 years]. To attain a stone free status, a second access tract was created in 12 cases, the mid

Table 1: Showing Salient Features

Laterality	No. Of cases	Percentage
Right	29	56.86
Left	22	43.13
STONE LOCATION:		
Pelvis	19	37.25 %
Upper ureteric	0 9	17.64 %
Partial staghorn	08	15.68 %
Upper calyx	09	17.64 %
Middle calyx	05	9.80 %
Inferior calyx	01	1.96 %
SUPRA COASTAL CALYX PUNCTURE SITE:		
Superior calyx	37	72.54
Middle calyx	13	25.49
Inferior calyx	01	1.96
LEVEL OF PUNCTURE:		
Supra 12^{th}	47	92.15
Supra 11^{th}	04	7.84
NO. OF ACCESS TRACTS:		
One	39	76.47 %
Two	12	23.52 %
PCN KEPT IN SITU	51	100%
Single PCN	39	76.47 %
Double PCN	12	23.52 %
PCN DURATION:		
24 hours	08	15.68
24-48 hours	25	49.01
Upto 72 hours	14	27.45
>72 hours	4	7.84
ADDITIONAL PROCEDURES:		
ESWL	1	1.96 %
URSL	1	1.96 %
PRIOR ESWL	6	11.76
PRIOR PCNL	2	3.92
STONE OPACITY:		
Opaque	ALL	100%
Lucent	-	-
HOSPITAL STAY		
24-48 hours	31	60.78 %
48-72 hours	15	29.41 %
72-96 hours	05	9.8 %

calyx had to be accessed in 9 and the inferior calyx in 3 cases

Six patients (11.76 %) had previously undergone ESWL for their stones and presented with intact stones. Prior PCNL had been done in 2 cases (3.92 %) and had significant residual stones. The mean stone size was 2.32 cm and the mean duration of the procedure was 69.13 minutes, measured from the time of puncture to the insertion of the nephrostomy tube. Post- operatively nephrostomy tubes were inserted in all patients, in patients with additional access tracts, double PCN tubes were kept in situ for adequate drainage. Complete stone clearance was observed in 44 cases (86.27%), significant residual stones were present in 2 cases (3.92 %). One patient with residual calculi underwent ESWL during follow up and ureteroscopic stone removal was done in 1 case after a duration of 1 month. Insignificant residual calculi were observed in 5 cases (9.8%). A total of 46 cases (90.19 %) became stone free after the primary procedure or after ancillary procedures. The mean duration of hospitalization was 2.49 days.

Complications developed in 6 patients (11.76%), (Table **2**), intra-operative bleeding being the most common, was seen in 4 patients (7.84 %). Intra-operative bleeding was considered significant if bleeding reduced the visibility during the procedure or if there was hemodynamic instability manifested by tachycardia or decreased blood pressure during the procedure or in the post-operative period. Hemoglobin levels decreased to 8 g/dl in 2 such patients and 2 units of packed RBC were administered in the post-operative period in both patients (3.92%). 2 patients (3.92%) had difficulty in breathing post-operatively in whom CXR showed obliteration of the costo-phrenic angle, a chest tube with water seal drain was inserted in 1 patient who had supra 11th access with significant pleural fluid collection and approx. 180 ml of fluid was drained immediately. The chest tube was subsequently removed on the 4th post-operative day when the column stopped moving and the breath sounds were heard normally, and were equal on both sides. Of the 6 patients with complications, 3 patients (5.8 %) had fever which subsided with broad-spectrum antibiotics within 48 hours.

Table 2: Complications of Supra-Costal PCNL

Hemorrage	4	7.84 %
Hemorrage needing blood transfusion	2	3.92 %
Fever > 38.5 c/ urosepsis	3	5.8 %
Pleural effusion	2	3.92 %
Hemothorax	Nil	-
Inter-coastal drain insertion	1	1.96 %
Complications related to icd	Nil	-
Reno-pleural fistula	Nil	-

DISCUSSION

Knowledge of the anatomic orientation of the kidney and the surrounding organs, diaphragm and pleura is important for the correct approach to a supra-coastal renal access [7]. The upper part of the kidney lies against the posterior part of the 11th and 12th ribs. The diaphragm is attached to the inferior border of the 12th rib, transverse process of the first lumbar vertebra and the anterior surfaces of the upper lumbar vertebra. Therefore, all punctures above the 12th rib pierce the diaphragm, the parietal pleura is reflected to the level of 10th rib in the mid-axillary line and variably along the 12th rib posteriorly. Usually it crosses the 12th rib at its centre, and the lateral half of this rib is inferolateral to the pleura. Injury to the parietal pleura can be avoided by staying above the lateral half of the 12th rib.

In 76.47 % of cases, a superior calyceal approach was undertaken in the present study, the advantages of this route include direct access to the upper-pole calyx, pelvis, inferior calyces, puj, proximal ureter and the ability to perform antegrade endopyelotomy for PUJ obstruction if necessary [2,8,9]. The anatomy of the kidney also favours the superior calyx approach as the lower pole of the kidney is tilted anteriorly because of the slope of the psoas muscle [8]. Access through the superior posterior calyx provides a short and straight tract along the axis of the kidney, causes less torque of the rigid nephroscope, and reduces the chance of injuring the peri-infundibular vessels that might occur if angulation of the tract is required to reach the stone [8]. Moreover this route also reduces injury to renal parenchyma by the Amplatz sheath or nephroscope during respiratory excursion [10,11]. Though we used larger Amplatz sheath of 28 to 30Fr but smaller sheath of 24- 26 sheath is preferable in supracostal PCNL to reduce the pain and other complications. The superior calyx lies above the 12th rib most of the time, also on full expiration 80% of right renal upper pole calyces and 85% of left renal upper pole calyces lie above the 12th rib [12], In addition, Preminger *et al*. described cephalad movement of the kidneys in the prone position by an average of 2.2 cm when viewed on IVP.

Thus direct access to a superior calyx would require a supracostal puncture in >80% of patients [13].

Sampaio *et al*. [14] in his studies showed that injury to an interlobar vessel occurred in 67% of kidneys on puncturing the upper-pole infundibulum and in 13% of kidneys when puncture was made through the lower-pole infundibulum. And the safest puncture was the one passing through the center of the calyceal papilla. Establishing an optimal percutaneous access appears to be the key determinant of PCNL-related blood loss [15].

Thus while making a superior calyceal tract, care should be taken to puncture through the center of the calyceal papilla, and direct puncture into the pelvis and near the infundibular neck must be avoided.

In 23.52% cases second tract was made, for stone clearance from the stone extension in the calyces. Although the posterior superior calyceal approach provides good visualization of the pcs, but, anterior superior and middle calyces may still be difficult to reach via this entry and may require separate punctures and access routes if stones are present in such locations [2,8,16]. Aggressive PCNL using multiple tracts provide optimal access to the entire collecting system for maximum clearance and have been reported to be safe and effective without any increase in intra-operative complications or transfusion requirements [17], also, using multiple tracts when necessary prevents excessive torque to gain entry into adjacent calyces, which may cause infundibular tear and bleeding.

Gupta *et al*. reported that 15 of 26 (58%) patients with staghorn calculi also required a middle calyceal puncture, as the middle calyx was difficult to reach from the superior calyx, because of the acute angle between the calyces [8].

Shaban *et al*. used PCNL in 11 patients with staghorn stones via two access tracts, one of which was supracostal and the other through the middle or the lower calyx. All renal units were managed in one session of PCNL, eight (72.72 %) were rendered stone-free and three (27.27%) required ESWL [18].

Our analysis revealed stone clearance rates of 86.27 % by PCNL monotherapy that are comparable with those noted by Kekre *et al*. 79.5%, [19] and Golijanin *et al*. 87% [20], the overall success rate of 90.19 is similar to that mentioned in the literature regarding supracostal PCNL procedures [4,16,19,20].

In all cases with double access tracts, 2 nephrostomy tubes were kept for adequate drainage of the renal units in the post-operative period as inadequate drainage was suggested to be a cause for thoracic complications in renal units with supra-coastal punctures [8]. However, a single re-entry nephrostomy tube through the superior calyx can be used in view of less morbidity and easier manageability [8].

Coming to complications with the supracostal access, hemmorhage in 7.84 % of cases ,was the most common complication in the present study and in 2 patients (3.92%) 2 units of packed cell transfusion were required in the post-operative period with supra 12^{th} access. On the basis of anatomic considerations, the intercostal access route might have a higher chance for injury to anterior segmental vessels or even anterior and posterior divisional arteries [9,10,21]. Although procedural blood loss during tract dilation followed by nephroscopy and stone extraction is expected, it is tamponaded by the Amplatz sheath intra-operatively and also by the nephrostomy tube in the post-operative period. Reported transfusion rates in the literature vary from 0-20% [19,20], hemorrhage was the most common complication described by Munver *et al.* [4] in his critical analysis of supracostal access for percutaenous renal surgery. In his series 5.5% of cases with supra 12^{th} access developed hemorrhage requiring transfusion, whereas none of the cases with supra 11^{th} access required transfusion. Kukreja *et al.* reported that the most important risk factor associated with blood transfusion requirement was existing anemia in addition to which, a prolonged operative time, multiple-tract procedures and intraoperative complications were associated with significantly increased blood loss during PCNL [15]. Previously published series, do not show an increased percentage of bleeding in patients undergoing supracostal access [4,8,22]

Injury to the intercostal artery leading to haemothorax is a potential complication which can be avoided by staying immediately above the upper border of the lower rib. [17].

Anatomically, the supracostal puncture passes through skin, subcutaneous tissue, latissimus dorsi, intercostal muscles, and diaphragm and into the kidney through Gerota's fascia and perinephric fat. For a proper supracostal approach, coordination with the anesthetist is required to control respiration. During full expiration, the needle is passed through the retroperitoneum and diaphragm to prevent injury to the

lung. The needle is then passed through the parenchyma to the collecting system, during deep inspiration for downward displacement of the kidney

Hopper and Yakes [23] performed computed tomography scan with sagittal reconstruction at both maximal inspiration and expiration. They reported that in the prone position, with expiration, the needle path had a 29 % chance on the right, and 14 % chance on the left, of transgressing the lung or pleura, while during maximal inspiration the lung would be in the path of the needle in 86% on right side and 79 % on the left side in the 11^{th}-12^{th} intercoastal approach. Access through the pleural space can lead to hydrothorax, requiring the insertion of a chest tube if severe.

A difference in the supra-12^{th} rib access tract, which is transthoracic but extrapleural, and the supra-11^{th} rib access tract, which is transthoracic and transpleural , was found to be the incidence of intrathoracic complications of supra 11^{th} access, which was 16-fold greater than the 1.4% for supra-12^{th} rib access and 46-fold greater than the 0.5% for subcostal access [4].

The occurrence of hydrothorax has been reported between 1–15% in various studies [5,8,19,25]. A snugly fit access sheath which prevents fluid backflow from the collecting system into the pleural cavity in trans-pleural access, guarding against the nephroscope occluding the collar of amplatz sheath for accessing a distant calculus and also maintaining low-pressure irrigation during the procedure may help to reduce fluid egress from the sides of the access sheath, and minimizes the risk of extravasation and pleural effusion [3], a well-draining nephrostomy will also minimize the leakage of urine into the pleural space [8].

In our study hydrothorax developed in 2 patients (3.92%) ,out of which ICD insertion was done in one patient (25 %) of the 4 patients with supra 11^{th} access, the ICD was removed on the 4^{th} post-operative day when the column had stopped moving and the chest sounds were equally heard bilaterally and CXR was normal. None of the patients had a lung injury in the present series. The occurrence of pleural effusion in present study were comparable with those of earlier studies (1.7 %– 15 %) [4,5,19,20] and all of them improved with conservative measures or ICD insertion. Yadav *et al*. [10] in their series reported 3.31% incidence of pleural injury presenting with fluid in the chest, which included three (75%) of the four patients who had the puncture made above the 11th rib, their mean duration of chest drainage, was 24 hours and hospital stay was not significantly prolonged as a result of the pleural breach in any patient.

Other thoracic complications mentioned in the literature include pneumothorax, haemothorax and nephropleural fistula, none of which were seen in the present study. If a renal surgery has been performed previously the kidney may be fixed higher in the retroperitoneum and may require a high puncture (above the 11th rib) to access the upper calyx, which may be associated with a higher rate of pleural complications [22]. Three patients (5.8%) with supra 12^{th} access developed fever in the post-operative period and were managed with IV antibiotics, and other supportive measures. None of the patients had a nephro-pleural fistula or peri-nephric collection, there were no cases with surrounding organ injury.

CONCLUSION

The supracostal approach provides optimum access, excellent visualization of most calyces , reasonable operative times along with comparable blood loss and stone clearance rates for most renal and upper ureteric stones, although thoracic complications are slightly higher than with a subcostal approach , adequate precautions like puncturing in full expiration, sufficiently laterally, routine use of a working sheath during nephroscopy and inserting a well-draining nephrostomy tube after the procedure may help prevent these complications . Secondary access tracts may be necessary for achieving stone clearance. The thoracic complications, mostly can be managed conservatively. Placing a chest tube may be required in some cases. Post-operative CXR should be done to rule out any pleural collection.

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