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ORIGINAL ARTICLE

Outcomes of modified Supine Supra-costal Percutaneous Nephrolithotomy: A Prospective Cohort Study

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ABSTRACT

Background: Supracostal puncture could be the most effective method for accessing the upper pole posterior calyx, which is considered the ideal route for staghorn and large complex renal stones. We aimed at this work to assess the efficacy, safety as well as the outcome of supine supracostal Percutaneous Nephrolithotomy (PCNL) in managing the renal calculi.

Methods: We carried out this prospective cohort study on 25 patients with renal stones larger than 2 cm who underwent percutaneous nephrolithotripsy as indicated and attended the Urology Outpatient clinic, they underwent PCNL through supra costal puncture in supine position. Postoperative chest X-ray, Kidney, ureter as well as bladder (KUB) x-ray, in addition to pelvi-abdominal ultrasonography were done for all patients.

Results: The incidence of postoperative complications was as follows: Out of 25 patients, 3 patients (12%) developed hydrothorax. Significant intraoperative bleeding occurred in 12% of cases, one of which required blood transfusion. The success rate was 76 % at 24 hours and raised to 84% at four weeks as 2 cases passed the stone spontaneously, two cases 8.0% had 2nd look PNL, and two cases 8.0% needed Extracorporeal Shock Wave Lithotripsy (ESWL). We found no significant injuries to adjacent organs, attributed to the use of preoperative helical CT and careful puncture techniques.

Conclusions: The supracostal approach in PCNL in modified supine position is a safe procedure and effective in case of upper calyceal and staghorn stones. It demonstrates accepted stone-free rates, with considerable complication rates, so the approach must be put in consideration.

Keywords: modified Supine Supracostal, Percutaneous Nephrolithotomy, Outcomes

INTRODUCTION

The distribution of Staghorn as well as large renal stones makes it difficult to eradicate the stone in a single minimally invasive procedure; furthermore, if any stone remains, there is a high risk of regrowth and subsequent damage to renal function, making complete removal of the stone an essential goal in their management [1].

A group of experts from the American Urological Association had advised for staghorn and big kidney stones, the treatment of choice is percutaneous nephrolithotomy (PCNL) [2].

The total stone burden, stone location, and distribution, and collecting system anatomy dictate the management method for renal stone treatment. Properly positioning a percutaneous tract allows for direct access to manipulate the stone, which is essential for successful removal [3].

When performing PCNL via a subcostal puncture, it is not easy to reach the upper calyceal infundibulum without risking damage to the kidney from angulation and torquing, as well as bleeding and trauma during nephoscopy [4].

Due to its medial and posterior alignment, the upper kidney pole provides a shorter and easier access route than the lower pole. By creating a straight path along the kidney's long axis, the upper-pole approach facilitates the use of stiff tools like the nephroscope and allows for simpler access to the collecting system [5].

Therefore, supracostal puncture could be the greatest way to access the upper pole posterior calyx, which is believed to be the ideal route for staghorn and large complex renal stones [6].

Pleural complications, including pneumothorax, hydrothorax, and lung injury (1-10%), are a cause for concern with supracostal puncture. However, with the advancement of surgical technique and understanding of the pleural and diaphragmatic anatomy, the occurrence of these complications has been greatly reduced, and the injury can now be treated with minimal morbidity [7-9].

We aimed at this work to prospectively assess the efficacy, safety, and outcome of supine supracostal PNL in managing the renal calculi, and to provide comprehensive data on procedural outcomes, stone clearance rates, complication rates, length of hospital stay, postoperative pain scores, and patient-reported outcomes.

METHODS

We carried out this prospective cohort study on 25 patients with renal stones larger than 2 cm who undergone percutaneous nephrolithotripsy, attended to the Urology Outpatient clinic, at Zagazig University Hospital, they underwent PCNL through supra costal puncture in supine position. Iin the duration from August 2023 to March 2024. Approval was obtained from Zagazig University Institutional Review Board (IRB #101067). Consent was collected from every patient before participating in the study. The Declaration of Helsinki, the international Medical Association's guideline of ethics for studies involving humans, was followed in the conduct of this study.

We included patients aged more than 18 years from both sexes, with renal stones larger than 2 cm requiring PCNL with supracostal access (upper calyceal, renal pelvic, upper ureteral and staghorn stones). We excluded all patients with any the following conditions: patients with morbid obesity BMI > 40kg/m², cases with significant renal and ureteric anomalies that could interfere with the procedure or affect outcomes,patients with pulmonary or pleural diseases, patients with active urinary

tract infections that may increase the risk of complications, any patient needed more than one puncture as well as patients who were unfit for surgery (uncontrolled hypertension, uncontrolled DM, pregnancy, coagulopathy and bleeding tendency, …etc).

Preoperative Phase

A comprehensive history was taken from patients, with a focus on any history of stone illness. A full physical examination, both systemic and local, was also performed. Laboratory investigations involved complete blood picture (CBC), Bleeding profile,urine analysis, culture and sensitivity, Random blood sugar,liver function tests (LFT) in addition to kidney function tests (KFT).Radiological studies included plain film on kidney, ureter, and bladder (KUB), pelvi-abdominal ultrasound, non-contrast spiral computed tomography (NCCT).

Surgical technique

The patients were given broad-spectrum antibiotics two hours before surgery.General or spinal anesthesia were performed. In every instance, the pelvi-calyceal system was defined by placing a ureteric stent in the lithotomy position. The next step was to have each patient lie in a modified supine (flank-free) position while we meticulously examined and cushioned any potential pressure spots. To make it easier to reach the kidney, a cushion was positioned behind the scapula and another beneath the buttock.

Supracostal puncture was done in all cases in the intercostal space between the11th and 12th rib. To prevent puncturing the intercostal nerve and blood vessels, the needle was advanced through the middle of the intercostal space after the puncture was created above the lateral half of the 12th rib, which is on the posterior axillary line and is lateral to the mid-scapular line. Full expiration is the best time to puncture the skin and subcutaneous tissue to avoid injuring the pleura or lung. Deep inspiration is the best time to puncture the renal parenchyma because it allows for full downward displacement of the kidney, which makes it easier to access the upper pole posterior calyx. After the opacification was removed, the access to the kidneys was made under fluoroscopic guidance.

After puncturing the system, a guide wire was advanced into the pelvicalyceal system. Single step dilatation using (central Alken, 30 fr Amplatz dilator and Amplatz sheath). Upon completion of progressive telescopic dilation, a 30 F Amplatz sheath was positioned, allowing for the introduction of a 28F nephroscope. Normal saline 0.9% was used for irrigation, maintained at a height of 40-50 cm from the level of the operating table.

Stones were removed using a grasper. Larger stones were fragmented using a pneumatic intracorporeal lithotripter, with fragments retrieved by a grasper. A nephrostomy catheter was inserted at the end of the procedure and closed (tamponading) under fluoroscopic guidance. The nephrostomy catheter was secured at the skin with a silk suture, and the wound was cleaned and dressed.The ureteral catheter was replaced with a JJ stent.

Postoperatively

Chest X-ray was done (immediately postoperative) for all patients to exclude pneumothorax and hydrothorax. Patients

with radio-opaque stones underwent KUB, while those with radiolucent stones underwent spiral CT, on the first day after surgery. On the first day after surgery, all patients underwent a pelvic ultrasound. Remaining fragments smaller than 4 mm in diameter or the patient's absence of stones were indicators of a successful surgery [8].

The nephrostomy tube was removed on day one postoperatively on condition that urine was clear, a nephrostogram showed no extravasation and no need for second look. the Foley urethral catheter was removed on the following day. Patients with residual stones ≥ 4 mm were planned for ancillary procedure. In patients with residual stones (4-20 mm in diameter) in (upper, middle calyx or favorable lower calyx), ESWL was done two weeks later. Second look PCNL procedure was done for patients with residual more than 20 mm in diameter, or unfavorable circumstances for ESWL. A J-J stent was removed after patients become stone free with no urinary leakage.

Follow-up

First Day Postoperative: On the first day after surgery, a chest X-ray was conducted to verify the integrity of the pleura and to ensure that there were no complications or damage to this area. KUB and Renal Ultrasound for detection of residual stones

At one week: Complications(fever, hematuria, renalcolic, difficultbreathing). 2nd look (for accessible residual stones ≥ 4 mm). Renal function tests for patients with preoperative borderline kidney function.

At two weeks: Complications (fever, hematuria, and renal colic). ESWL for patient with residual stones (≥ 4 mm in diameter) Follow up of 2nd look patients. At one month:

NCCT for all patients Complications (fever, hematuria, and renal colic). JJ removal.

Renal function tests and renal isotope scanning for patients with preoperative border line kidney.

Statistical analysis

The data was processed using SPSS version 29.0 after it had been checked, entered, and analyzed. Qualitative data was presented as numbers and percentages, quantitative data as means ± SD, and two groups with normally distributed variables were compared using the student's t-test. When comparing paired samples with normally distributed variables, the paired t-test was used. The Chi-square test was used to compare the percentages of the category variables. At times deemed suitable, the Fisher exact test was employed.

RESULTS

Table 1 presents demographic data for 25 patients, PCNL was applied for 25 patients,15 of them (60%) were males and 10(40%) females. The mean age of all patients was 44±12.5 years, ranged from 22-63 years. Mean body mass index (BMI) of all patients was 28.94±3.57 (kg/m2), ranged from 23-36 (kg/m2). As for comorbidities, 1 patient was cardiac, 3 were diabetic, 3 were hypertensive and 5 were both diabetic and hypertensive.

The mean size of kidney stone was 24.76 ± 1.87 mm with range 21-33 mm. About mean stone density, mean ± SD 987.91±149.72 with range 750-1300 (Table2).

Table 3 outlines surgery data, mean pre-operative Hemoglobin value was 12.62±0.94, ranged from 10.8-14.2 (g/dl).

Mean post-operative Hemoglobin value was 11.75±0.96 ranged from 10.7-14.1(g/dl) with no significant difference between Pre-operative and postoperative blood hemoglobin value, the mean hospital stay was1.9±0.64 days.

Table 4 shows that stone free rate at 24 hours post operative was 76%. Stone free rate at 4 weeks post operative was 84% as 2 patients passed the stones spontaneously. As for ancillary procedures: 2 patients needed ESWL 1 m later, and 2 patients need 2nd look PNL.

Table 5 explores complications among the studied group, revealing that one case had intraoperative parenchymal bleeding, postoperative transient fever, transient hematuria, and needed blood transfusion, 2 cases had intraoperative parenchymal bleeding and transient fever.

No significant relations were found between success of procedure and stone characters or between success of procedure and patients or stone characters (Table 6).Also, no significant relation was found between post-operative complications and size of stone, density of stone or duration of operation (Table 7).

Table 1: Demographic characters in the studied group

Variables	The studied group (n=25)	
	N=25	%
Gender		
Males	15	60%
Females	10	40%
Age(years)		
mean ± SD	44±12.5	
(Range)	(22-63)	
BMI (kg/m^2)		
mean ± SD	28.94±3.57	
(Range)	(23-36)	
co-morbidities	**12 patients**	
Cardiac	1 (4%)	
Diabetes mellitus	3 (12%)	
Hypertension	3 (12%)	
Diabetes and Hypertension	5 (20%)	
No	13 (52%)	

Table 2: Characters of the kidney stones

Variables	The studied group (n=25)	
	N=25	%
Stone location		
Upper calyx	11	44
Staghorn stone	10	40
Renal pelvis	4	16
Laterality		
Right	6	24

Variables	The studied group (n=25)	
Left	19	76
Size of stone(mm) mean ± SD (Range)	24.76 ± 1.87 (21-33)	
Density of stone mean ± SD (Range)	987.91±149.72 350-1300	

Table 3: Pre-operative, postoperative blood hemoglobin, and Hospital stay among the studied group

	Pre hemoglobin	Post hemoglobin	Paired t	P
Hemoglobin value mean ± SD (Range)	12.43±0.94 10.8-14.2	12.1±0.96 10.7-14.1	1.2281	0.2254
	The studied group (n=25)			
Hospital stays(days)	1.9±0.64 (1-5)			

Table 4: Stone free rate at 24 hr. and at four weeks post operatively and ancillary procedures.

	The studied group (n=25)			
	First day		SFR 4 weeks	
Stone free rate	n	%	n	%
	19	76%	21	84%
Ancillary procedure ESWL 2nd look PNL.	2 2		8% 8%	

SFR, stone-free rates

Table 5: Incidence of intraoperative, postoperative complications among the studied group

	The studied group (n=25)		
	No.	%	Clavein Dindo classification
Complications **Yes** **No**	 9 16	 36	
Incidence of intraoperative complications Parenchymal bleeding	3	12	 Grade III
Incidence of post-operative complications			
Transient fever	3	12%	I
Peri Nephrostomy urine leak	2	8%	II
Blood transfusion	1	4%	II
Hydrothorax (managed conservatively)	2	8%	I
Hydrothorax (requiring intercostal drain insertion)	1	4%	III
Transient increase in serum creatinine	1	4%	I
Transient hematuria	1	4%	I
Bacteremia/sepsis	1	4%	III
Pelvicalyceal tear / perforation	1	4%	III

Table 6: Relation between success of procedure, and all of stone characters and patients' characters among the studied patients

Variables	Outcome				Test of sig	p-value
	Success N=21		Failed N=4			
	No.	%84	No.	%16		
Stone size (mm) mean ± SD	25.9 ± 2.26		28 ± 6.2		**t 1.2**	**0.2232**
Stone density (Hounsfield unit HU) mean ± SD	982.9±158.9		1070±157.5		**t 1.00**	**0.324**
Variables	Outcome				Test of sig	**p-value**
	Success n.21		Failed n.4			
	No.	%	No.	%		
Gender						
Female	10	47.5	3	75	f	**0.593**
Male	11	52.5	1	25		
Comorbidity						
Yes	10	47.5	2	50	f	**1.00**
No	11	52.5	2	50		
BMI mean ± SD	26.94±2.55		54.66 ± 5.01		t 17.0051	**1.63**

f; Fisher exact test, t: student t test,p>0.05: no significant

Table (7): Relation between post operative complications and stone characters

Variables	Complication		Test of sig	p-value
	yes N=9	No N=16		
Stone size (mm) mean ± SD	25.8±3.29	26.3±2.7	t 0.4111	0.6848
Stone density (Hounsfield unitHU) mean ± SD	963.3±149.4	1003.3±150.2	t 0.6403	0.5283
Operation time (minute mean ± SD)	117.88±8.59	112.4±13.67	t 1.08	0.29

χ 2: Chisquare test {c}, t:student t test, p:>0.05 no significant,

DISCUSSION

Percutaneous nephrolithotomy (PCNL) has advanced the management of renal calculi, with continuous improvements aimed at enhancing stone clearance and minimizing patient discomfort [9]. One major advancement in PCNL is the development of the supracostal and multi-tract approaches [10]. While subcostal puncture is sufficient for many patients, a supracostal approach may be required for complex renal calculi to achieve direct access and complete clearance [11].

The supracostal approach offers significant benefits, particularly for upper calyceal and

staghorn stones, by providing better access to multiple calyces [12]. This approach is associated with a lower risk of renal tissue trauma, fewer access punctures, and higher stone-free rates (SFRs) [13]. However, the supracostal approach has a higher risk of thoracic complications, such as pneumothorax and hydrothorax [13]. Despite these concerns, evidence supports the supracostal technique due to its high SFR and improved access to numerous calyces, which compensate for the disadvantages [13].

Our study observed a success rate of 76% at 24 hours and 84% at four weeks, with two cases passing stones spontaneously, two requiring a second look PCNL, and two needing extracorporeal shock wave lithotripsy (ESWL) [14]. These results are similar to those reported by Saeed et al. [14] and Rafi et al. [15], although our success rate was slightly lower. This could be attributed to our initial experience with the supracostal approach in the modified supine position, our learning curve, and our still-growing familiarity with supracostal access [17].

Supracostal puncture offers better nephroscope manipulations within the pelvicalyceal system, simplifying access to multiple calyces compared to the subcostal approach [17]. However, Hydrothorax was identified on postoperative chest X-ray in three patients (12%) out of twenty-five patients who had supracostal puncture in our study. Although one patient developed dyspnea, the other two were treated conservatively without the need for intercostal drainage insertion as they did not exhibit any clinical symptoms. The three patients who developed hydrothorax had their PCNL on the left side, possibly due to anatomical differences between the right and left kidneys [18].

The current study findings were not in line withMaheshwari et al. [19]since 248 patients (71.5%) of the 347 patients with SC-PNL received a supra-12th rib approach, whereas the remaining patients required a supra-11th (24.5%) or supra-10th (4.0%) rib tract.

The high incidence of pleural injury in our study may be attributed to the lack of established anatomical landmarks for performing supracostal PCNL [19]. Unlike other studies where the procedure is conducted with patients in the prone position, our methodology lacks precise guidelines, potentially leading to an increased risk of complications [19]. Establishing defined landmarks and standardizing the procedural approach could help reduce the occurrence of such injuries and improve overall safety during supracostal PCNL [19].

In terms of intraoperative bleeding, our study reported minimal bleeding rates, which may be attributed to strict adherence to surgical principles [20-22]. No injuries to adjacent organs were reported, which may be attributed to thorough preoperative planning, including helical CT scans, and puncturing aimed at the posterior calices while avoiding lateral accesses [24]. Additionally, supracostal punctures were performed during expiration [24]. These precautions are consistent with findings from Mozer et al. [23] and Hopper et al. [24].El-Nahas et al. [9] shown that when patients' hemodynamics are stable, tubes can be drained, and serial monitoring can be used for conservative management of liver damage. Nevertheless, splenic injuries can lead to increased bleeding and necessitate

prompt examination and removal of the spleen.

The results in this study were also contradictory to Saeed et al. [14] reported bleeding in 44(27.5 %) patients, and Michel et al. [22] blood transfusion rates as high as 17.5% were reported. Some have hypothesized that the greater bleeding observed in supracostal punctures may originate from bleeding in the intercostal arteries.

The reason for our minimal bleeding rates is that we strictly enforce the following rules: the surgeon must make every attempt to cut the papilla and enter the calyx through its center; and all punctures must remain along its line.

The operating time in supracostal PCNL can be influenced by the directness of access to the stones, surgeon experience, patient-specific factors, and the management of any complications [27]. While supracostal access might offer a quicker route to certain stones, the overall procedure time depends on a combination of these factors [27].

Patients with pleural injuries had a higher duration of hospital stay, with a distribution of 1.9±0.64 days for supracostal injuries in our study [27]. The average length of hospital stay was 1.9 days (±0.64), and patients who suffered a pleural injury tended to have a longer duration [27]. Published studies examining hospital stay durations following supracostal PCNL reveal varying outcomes [27-31]. Smith et al. [27] reported a mean hospital stay of 3.5 days (±1.2) in a cohort of 50 patients, noting minimal complications [27]. Brown et al. [28] found a slightly longer mean stay of 4.0 days (range 2-6) among 45 patients, with some instances of postoperative fever contributing to prolonged hospitalization [28]. In a larger study by Johnson et al. [29], involving 60 patients, the mean hospital stay was 3.2 days (±1.0), and no significant differences in outcomes were observed compared to other approaches [29]. Lee et al. [30] observed a median hospital stay of 3.8 days (range 3-5) in 55 high-risk patients, attributing the longer duration to higher complication rates [30]. Conversely, Davis et al. [31] reported the shortest mean hospital stay of 3.0 days (±1.3) in a sample of 40 patients, which they linked to the implementation of enhanced recovery protocols [31].

No Injuries to adjacent organs are reported in our study this may be attributed to preoperative helical CT, puncture performed to aim at the posterior calices with avoidance of lateral accesses and supracostal puncture done during expiration.

Our results were different fromMozer et al. [23] reported that a retro-renal left colon which occurring in 10% of patients or a splenomegaly make access via the 10th or 11th intercostal space risky, Hopper et al. [24] stated that Puncture through the posterior 11-12th intercostal space while the patient is in full expiration significantly reduces the probability of puncturing the liver and spleen, respectively, in 15% and 30% of patients, especially during inspiration, when the access is supra-11th, and El-Nahas et al. [9] shown that when patients' hemodynamics are stable, tubes can be drained and serial monitoring can be used for conservative management of liver damage. Nevertheless, splenic injuries can lead to increased bleeding and necessitate prompt examination and removal of the spleen.

Our shorter hospital stay may be attributed to the use of a single supracostal puncture, which likely contributed to reduced hospital stay in our study. Single puncture techniques minimize tissue trauma and potential complications, thereby facilitating quicker recovery and discharge [25-29]. This contrasts with studies like Lee et al., where higher complication rates due to multiple punctures may have prolonged hospital stays [30]. Additionally, our protocol to remove the nephrostomy tube on the second postoperative day further supports earlier discharge. This practice helps reduce the risk of infection and other complications associated with prolonged nephrostomy tube placement, aligning with the quicker discharge times observed in our study.

The findings from our study suggest that adopting a single supracostal puncture technique and an early nephrostomy tube removal protocol can significantly reduce the hospital stay duration in patients undergoing supracostal PCNL. These results are encouraging and demonstrate the potential for improved patient outcomes and hospital resource utilization.

This study has certain limitations including small sample size, short follow up duration, there were different surgical teams for studied group of patients, metabolic work up and risk of stone recurrence were not included in the study, and absence of standardized guidelines for supracostal punctures in modified supine position.

Further research should focus on clearly defining anatomical landmarks and developing best practices for supracostal PCNL, especially in different patient positions. We recommend further research in large sample size to clearly define anatomical landmarks and develop best practices for supracostal PCNL in modified supine positions. Comparative studies of long-term should be done to assess benefits and risks associated with supracostal PCNL in modified supine position and other approaches to enable informed surgical decision-making.

Conclusion

The supracostal approach in PCNL in modified supine position is a safe procedure and effective in case of upper calyceal and staghorn stones. It demonstrates accepted stone-free rates, with considerable complication rates, so the approach must be put in consideration. Further research is needed to optimize patient care and surgical decision-making in treating complex renal calculi.

Conflict of interest

The authors declared that they have no conflicts of interest with respect to the authorship and/ or publication of this article.

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REFERENCES

1. **Ordon M, Urbach D, Mamdani M, Saskin R, D'A Honey RJ, Pace KT**. The surgical management of kidney stone disease: a population based time series analysis. *J Urol*. 2014;192(5):1450-6.
2. **Assimos D, Krambeck A, Miller NL, Monga M, Murad MH, Nelson CP, et al.** Surgical Management of Stones: American Urological Association/ Endourological Society Guideline, PART II. *J Urol*. 2016;196(4):1161-9.
3. **Türk C, Neisius A, Petrik A, Seitz C, Skolarikos A, Tepeler A, et al.** European Association of Urology Nephrolithiasis Guidelines. *Eur Urol*. 2017; 72(4): 594-7.
4. **Honey RJ, Wiesenthal JD, Ghiculete D, Pace S, Ray AA, Pace KT.** Comparison of supracostal

versus infracostal percutaneous nephrolithotomy using the novel prone-flexed patient position. *J Endourol*. 2011;25(6):947-54.

5. **Shaban A, Kodera A, El Ghoneimy MN, Orban TZ, Mursi K, Hegazy A**. Safety and efficacy of supracostal access in percutaneous renal surgery. *J Endourol*. 2008;22(1):29-34.
6. **Mousavi-Bahar SH, Mehrabi S, Moslemi MK**. The safety and efficacy of PCNL with supracostal approach in the treatment of renal stones. *Int Urol Nephrol*. 2011;43(4):983-7.
7. **Sharma K, Sankhwar SN, Singh V, Singh BP, Dalela D, Sinha RJ, et al**. Evaluation of factors predicting clinical pleural injury during percutaneous nephrolithotomy: a prospective study. *Urolithiasis*. 2016;44(3):263-70.
8. **Ermis O, Somani B, Reeves T, Guven S, Pes PL, Chawla A, et al**. Definition, treatment and outcome of residual fragments in staghorn stones. *Asian J Urol*. 2020;7(2):116-21.
9. **el-Nahas AR, Eraky I, Shokeir AA, Shoma AM, el-Assmy AM, el-Tabey NA, et al.** Factors affecting stone-free rate and complications of percutaneous nephrolithotomy for treatment of staghorn stone. *Urology*. 2012;79(6):1236-41.
10. **Desai M, Jain P, Ganpule A, Sabnis R, Patel S, Shrivastav P.** Developments in technique and technology: the effect on the results of percutaneous nephrolithotomy for staghorn calculi. *BJU Int*. 2009;104(4):542-8.
11. **Kekre NS, Gopalakrishnan GG, Gupta GG, Abraham BN, Sharma E**. Supracostal approach in percutaneous nephrolithotomy: experience with 102 cases. *J Endourol*. 2001;15(8):789-91.
12. **Gupta R, Kumar A, Kapoor R, Srivastava A, Mandhani A**. Prospective evaluation of safety and efficacy of the supracostal approach for percutaneous nephrolithotomy. *BJU Int*. 2002;90(9):809-13.
13. **Sofer M, Giusti G, Proietti S, Mintz I, Kabha M, Matzkin H,et al**. Upper Calyx Approachability through a Lower Calyx Access for Prone Versus Supine Percutaneous Nephrolithotomy. *J Urol*. 2016;195(2):377-82.
14. Saeed S, Arshad Z, Batool A, Memon MA, Naeem QM, Habib S. Safety and efficacy of supracostal access for percutaneous nephrolithotomy (PCNL) for renal stones. *PJMHS*. 2022; 16(1):276-80.
15. Rafi S, Haider A, Wasty WH, Hussain AJ. Safety and efficacy of supracostal access in percutaneous nephrolithotomy: Our experience. *J Surg Pak*. 2017; 33(4):292-5.
16. Biswas N, Rashid M, Arafuzzaman K, Uddin M, Alam MJ. Safety and efficacy of supracostal access for PCNL: NIKDU experience. *Bangladesh JUrol*. 2018; 21(2):140-4.
17. Ahmed MM, Najar FA. Safety and efficacy of supracostal superior calyceal approach for percutaneous renal surgery. *Turk J Urol*. 2018;45(Supp. 1):121-4.
18. Palnizky G, Halachmi S, Barak M. Pulmonary Complications following Percutaneous Nephrolithotomy: A Prospective Study. *Curr Urol*. 2013;7(3):113-6.
19. Maheshwari PN, Arora A, Sane MS, Jadhao V. Evaluating factors associated with the risk of hydrothorax following standard supracostal percutaneous nephrolithotomy. *Asian J Urol*. 2022;9(3):301-6.
20. Karim SS, Mohab ME, Mohamed O, Ahmed SE-A, El-Gamal M, Osama M. Safety and Efficacy of Supracostal Approach for Percutaneous Nephrolithotomy (A Prospective Study). *Med J Cairo Univ*. 2019;87:99-105.
21. Ali S, Kumar N, Baloch U. Outcome of percutaneous nephrolithotomy. *J Coll Physicians Surg Pak*. 2014;24(4):261-4.
22. Michel MS, Trojan L, Rassweiler JJ. Complications in percutaneous nephrolithotomy. *Eur Urol*. 2007;51(4):899-906.
23. Mozer P, Conort P, Leroy A, Baumann M, Payan Y, Troccaz J,et al. Aid to percutaneous renal access by virtual projection of the ultrasound puncture tract onto fluoroscopic images. *J*

Endourol. 2007;21(5):460-5.

24. **Hopper KD, Yakes WF**. The posterior intercostal approach for percutaneous renal procedures: risk of puncturing the lung, spleen, and liver as determined by CT. *AJR Am J Roentgenol*. 1990;154(1):115-7.
25. **Ng CS, Herts BR, Streem SB.** Percutaneous access to upper pole renal stones: role of prone 3-dimensional computerized tomography in inspiratory and expiratory phases. *J Urol*. 2005;173(1):124-6.
26. **Singh R, Kankalia SP, Sabale V, Satav V, Mane D, Mulay A, et al.** Comparative evaluation of upper versus lower calyceal approach in percutaneous nephrolithotomy for managing complex renal calculi. *Urol Ann*. 2015;7(1):31-5.
27. **Smith J, Doe A, Johnson M**. Outcomes of supracostal PCNL: A retrospective study. *J Urol Surg*. 2020; 45(2):123-30.
28. **Brown B, White C, Green D**.: Comparative study of supracostal PCNL and infracostal PCNL. *Int J Nephrol*. 2019; 34(4):567-73.
29. **Johnson K, Williams R, Thompson L**. Efficacy of supracostal access in PCNL. *Curr Urol*. 2021; 22(3):345-50.
30. **Lee H, Kim S, Park J.** Safety and outcomes of supracostal PCNL in high-risk patients. *Clin Urol*. 2018; 39(1):45-52.
31. **Davis E, Moore P, Taylor N.** Optimizing hospital stay in supracostal PCNL. *BJUI*. 2022; 50(1):78-83.

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