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Supracostal Approach for PCNL: Is 10th and 11th Intercostal Space Safe According to Clavien Classification System?

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The purpose of this study was to evaluate the success and morbidity of percutaneous nephrolithotomy (PCNL) performed through the 11th and 10th intercostal space. Between March 2005 and February 2012, 612 patients underwent PCNL, 243 of whom had a supracostal access. The interspace between the 11th and 12th rib was used in 204 cases (group 1) and between the 10th and 11th interspaces in 39 cases (group 2). PCNL was performed using standard supracostal technique in all patients. The operative time, success rate, hospital stay, and complications according to the modified Clavien classification were compared between group 1 and group 2. The stone-free rate was 86.8% in group 1 and 84.6% in group 2 after one session of PCNL. Auxiliary procedures consisting of ureterorenoscopy (URS) and shock wave lithotripsy (SWL) were required in 5 and 7 patients, respectively, in group 1; and in 1 patient each in group 2. After the auxiliary procedures, stone-free rates increased to 92.6% in group 1 and 89.7% in group 2. A total of 74 (30.4%) complications were documented in the 2 groups according to modified Clavien classification. Grade-I complications were recorded in 20 (8.2%), grade-II in 38 (15.6%), grade-IIIa in 13 (5.3%), and grade-IIIb in 2 (0.8%) patients; grade-IVa was recorded in 1 (0.4%) patient. There were no grade-IVb or grade-V complications. Overall complication rate was 30.9% in group 1 and 28.2% in group 2. Supracostal PCNL in selected cases is effective and safe with acceptable complications. The modified Clavien system provides a standardized grading system for complications of PCNL.

Key words: Percutaneous nephrolithotomy – Supracostal approach complications – Clavien classification – Kidney stone

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Percutaneous nephrolithotomy (PCNL) is the accepted treatment for staghorn stones, large renal stones, and some upper ureteric stones.[1] Optimal and atraumatic access to the desired calix is a vital step in a successful PCNL. Stone site and burden or calyceal anatomy may necessitate the need for upper pole renal access via a supracostal approach.[2] The indications for the upper pole approach are staghorn calculi, multiple calculi in the superior and inferior calyceal groups, and renal pelvis, and large upper ureteral calculi and calculi in specific anatomy. An access through the superior calix provides a straight tract along the long axis of the kidney with optimal visualization of the collecting system, and it is associated with less torquing, less bleeding, and ultimately better clearance. The advantage of the superior calyceal approach in percutaneous renal surgery has been reported by many authors.[2–7] However, it is usually a concern because of the potential complications of pneumothorax, hydrothorax, pleural effusion, and lung injury.

Although large-series PCNL results have been reported, there is still a lack of consensus on how to define complications and grade their severity. The Clavien classification system has been proposed to grade complications of general surgery.[8] The classification has recently been modified and tested in a cohort of 6336 patients who underwent elective general surgery,[9] it has also been studied by urologists for PCNL.[10–12] The modified Clavien classification system determines the severity of a complication by using a scale with 5 grades. Grade-I complications are designated as any deviations from the normal postoperative course that do not require extra therapy (with the exception of antiemetic, antipyretic, analgesic, and diuretic drugs). Grade-II complications necessitate pharmacologic treatment with drugs other than the drugs mentioned for the grade-I complications, as well as the need for blood transfusion or total parenteral nutrition. Grade-III complications are defined as complications necessitating surgical, endoscopic, or radiologic intervention. This grade is subdivided into grades IIIa and IIIb on the basis of the need for general anesthesia. Grade-IV complications are life threatening and necessitate intensive care, often leaving the patient with residual disability. This grade is subdivided into grade IVa and grade IVb owing to the number of affected organs. A grade-V complication represents the death of a patient as the result of the complication.[9]

To the best of our knowledge, until now no study has evaluated perioperative complications of supracostal PCNL using the modified Clavien classification. For this reason, we retrospectively evaluated the patients who underwent PCNL by an intercostal approach (10th or 11th intercostal space) at our institute.

Materials and Methods

Between March 2005 and February 2012, a total of 612 patients, mean age 47.3 years (range, 11–78 years) underwent PCNL in Izmir Bozyaka Training and Research Hospital, Izmir, Turkey. From these cases, supracostal approach was obtained in 243 cases (39.7%). The interspace between the11th and 12th ribs was used in 204 cases (83.9%) (group 1), and the interspace between the 10th and 11th ribs was used in 39 cases (16.1%) (group 2). Patients' data were collected from retrospective hospital records.

Patient assessment included medical history, urine culture, renal function tests, intravenous urography (IVU), ultrasonography, and/or abdominal computed tomography (CT). Stone burden was determined by multiplying stone length by width in millimeters as measured on IVU or CT in cases with radioluscent stones. Informed consent form was obtained from all patients.

Patient characteristics, number and location of the access point, operative and hospitalization time, stone burden, stone clearance, and complications were recorded. On the first day of the operation, all patients were tested for complete blood count (CBC) and any change in the hematocrit level. Postoperative chest X-ray was routinely done in all cases. Symptoms and chest X-rays were used to evaluate pulmonary complications. If the patients developed chest pain and chest X-ray revealed pleural effusion, a chest tube was inserted immediately. Kidney ureter bladder (KUB) film was performed on postoperative day 1 for evaluation of the residual stones.

Complications were recorded according to modified Clavien classification system. The success rate was defined as the absence of residual stone fragments. All symptomatic and larger asymptomatic fragments were considered significant enough to require secondary procedures [ureteroscopy, shock wave lithotripsy (SWL)].

Because of the known increased risk of pneumothorax or lung injury, access via the 10th interspace was avoided whenever possible.

Table 1 Stone location and stone size (mm)[a]

Stone location	Group 1		Group 2		*P* value[b]
	n	Stone size	n	Stone size	
Pelvis	97	551 ± 337	7	379 ± 255	0.98
Pelvis + lower caliceal	55	651± 315	0	NA	NA
Pelvis + upper caliceal	15	690 ± 541	4	635 ± 180	0.92
Staghorn	14	1163 ± 492	2	835 ± 261	0.28
Partial staghorn	9	1026 ± 651	5	922 ± 150	0.14
Caliceal	7	274 ± 129	12	334 ± 195	0.46
Pelvis + upper ureter	5	510 ± 289	4	225 ± 95	0.32
Upper ureter	2	195 ± 57	5	192 ± 93	1

NA, not applicable.

[a]Values are expressed as mean ± SD unless otherwise indicated.

[b]Mann-Whitney test.

Surgical technique

With the patient under general anesthesia, an open-end 6-F ureteral catheter was placed cystoscopically to opacify the collecting system. The standard percutaneous access was created in all patients. Under biplanary fluoroscopic guidance, in the prone position and after injection of contrast material through ureteral catheter, the needle was pushed through the diaphragm and retroperitoneum. All supracostal punctures were made in full expiration through the middle of the intercostal space. Once a 0.38-in guide wire was in position, the tract was dilated to 30 F using Amplatz dilators (Cook Urological, Spencer, Indiana). A 26-F nephroscope (Wolf, City, Germany) was used over the Amplatz sheath and the calculus was fragmanted using pneumatic lithotripter (Elmed, Ankara, Turkey) and extracted by grasper. If necessary, a flexible nephroscope (CYF-5, Olympus, Tokyo, Japan) and/or holmium YAG laser (Dornier Medilas H20, Shreveport, LA) was used for the stone that could not be reached with the rigid instrument. Fluoroscopy and contrast nephrogram were done to evaluate the stone-free status at the end of the operation. An 18-F nephrostomy tube was inserted for 24 or 48 hours.

Statistical analyses

Compliance with normal distribution of data was analyzed. Student *t* test was used for comparison of the normally distributed variable between the 2 groups, and Mann-Whitney test was used for non-normally distributed data. Complication and operative data of the 2 groups were compared using the χ^2 test and Fisher exact test. Odds ratios (OR) were calculated and statistical determinations were within 95% confidence interval (CI). All *P* values were 2-tailed, and $P < 0.05$ was considered statistically significant. The data were analyzed using SPSS statistical software package (SPSS Version 11.0, Chicago, IL).

Results

A total of 243 patients underwent supracostal PCNL procedures for renal stones between March 2005 and February 2012. Access to the kidney was supracostal in all cases. The interspace between the 11th and 12th ribs was used in 204 cases (83.9%; group 1), and the interspace between the 10th and 11th ribs was used in 39 cases (16.1%; group 2). Staghorns were found in 16 cases (6.5%), partial staghorns in 14 cases (5.7%), upper calyceal stones in 19 cases (7.8%), renal pelvis and lower calyceal stones in 55 cases (22.6%), pelvis and upper calyceal stones in 19 cases (7.8%), renal pelvis stones in 104 cases (42.7%), and upper ureteral stones in 7 cases (2.8%). Stones size and stone localization are shown in Table 1. A single tract access was used in 223 cases (91.7%), but in 20 cases (8.3%), a second access tract became necessary for better clearance. The stone-free rate was 86.8% in group 1 and 84.6% in group 2 after 1 session of PCNL. Auxiliary procedures consisting of ureterorenoscopy (URS) and SWL were required in 5 and 7 patients, respectively, in group 1; and in 1 patient each in group 2. After the auxiliary procedures, stone-free rates increased to 92.6% in group 1 and 89.7% in group 2. Patient demographics and operative data are summarized in Table 2.

Complications were recorded according to modified Clavien classification and are listed in Table 3. A total of 74 of 243 (30.4%) patients with complications were documented in 2 groups. Grade-I

Table 2 Descriptive data of 2 groups[a]

	Group 1 11–12 intercostal access	Group 2 10–11 intercostal access	*P* value
No. patients	204	39	
Age (range)	47.2 ± 12.5 (18–78)	48.2 ± 14.2 (11–73)	0.72[b]
Sex, M/F	143/61	27/12	0.91
BMI (range), kg/m^2	27.1 ± 4.4 (17.6–36.3)	24.4 ± 3.1 (19.5–29.1)	0.05[c]
Prior kidney operation	13	11	0.00[c]
Single access, n	186	37	0.35[c]
Second access, n	18	2	
10–11 Intercostal	2	0	
11–12 Intercostal	6	1	
Subcostal	10	1	
Mean fluoroscopy time, sec	117.6 ± 72.1	113.4 ± 49.9	0.79[b]
Mean operation time (range), min	75.8 ± 32.9 (35–145)	63.3 ± 29.2 (30–150)	0.24[b]
Stone-free rate			
After 1 session, n (%)	177 (86.8%)	33 (84.6%)	0.94[c]
After auxiliary procedure, n (%)	189 (92.6%)	35 (89.7%)	0.52[c]
Mean hemoglobin decrease, g/dL	1.94 ± 1.05	1.72 ± 1.15	0.34[b]
Mean duration with nephrostomy tube (days)	2.2 ± 0.8 (1–5)	1.9 ± 0.6 (1–5)	0.28[b]
Mean hospitalization (range) (days)	3.1 ± 0.9 (2–14)	2.9 ± 0.8 (2–11)	0.39[b]

BMI, body mass index.

[a]Values are expressed as mean ± SD unless otherwise indicated.

[b]Student *t* test.

[c]χ^2test.

complications were recorded in 20 (8.2%) patients, grade-II in 38 (15.6%), grade-IIIa in 13 (5.3%), grade-IIIb in 2 (0.8%), and grade-IVa in 1 (0.4%) patient. There were no grade-IVb or grade-V complications. Overall complication rate was 30.9% in group 1 and 28.2% in group 2.

Postoperative fever was seen in 23 patients. In 20 of these patients, fever resolved with antipyretics

Table 3 Complications according to the Clavien system

	Group 1 11–12 intercostal access	Group 2 10–11 intercostal access	*P* value[a]	OR	95% CI
Grade I	141 (69.1%)	28 (71.8%)	0.85	1.14	0.9–1.2
Grade II	17 (8.3%)	3 (7.6%)	0.59	1	0.3–2.7
Fever	17	3			
Grade III	33 (16.2%)	5 (12.8%)	0.81	1	0.9–1.2
Blood transfusion	22 (10.8)	3 (7.7%)			
Urine leakage <12 h	9 (4.4%)	1 (2.5%)			
Infection requiring additional antibiotics	2 (1%)	1 (2.5%)			
Grade IIIa	10 (4.9%)	3 (7.7%)	0.44	0.91	0.7–1.2
DJ stent placement for urine leakage	8 (40%)	1 (2.5%)			
Urinoma	2 (1%)	0			
Hydrothorax	0	2 (5.1%)			
Grade IIIb	2 (1%)	0	NA		
Extravasation requiring percutaneous drainage	1 (0.5)				
AV fistula	1 (0.5)				
Grade IVa	1 (0.5%)	0	NA		
Nephrectomy	1 (0.5)				

NA, not applicable.

[a]Fisher exact test and χ^2 test.

(grade I), but in 2 patients in group 1 and 1 patient in group 2 with infections, additional antibiotic therapy was needed (grade II). Blood transfusion was required in 25 (10.2%) patients, and urinary leakage from the nephrostomy site was seen in 10 (4.1%) patients (grade II). Urinary leakage was managed by temporary double-J (DJ) stent in 9 (3.7%) patients (grade IIIa). Hydrothorax occurred in 2 patients (0.8%) in group 2, but none of these patients needed intercostal drainage. Other individual complications accounted for less than 1% of patients. All grade-IIIb and grade-IVa complications occurred in staghorn-stone patients. All 3 patients who developed postoperative sepsis were staghorn-stone patients, and they had negative urine cultures preoperatively. Severe hemorrhage from the nephrostomy tract was seen in 1 patient who had renal pelvis and upper calyceal stones. He underwent nephrectomy because of formation of an arteriovenous (AV) fistula (grade IVa). Although operative time, complications, and Clavien score were higher in group 1, the difference was not statistically significant ($P > 0.05$).

Discussion

Percutaneous nephrolithotomy has replaced open stone surgery for large and complex renal or upper ureteral calculi because it is a minimally invasive technique.[1] The outcome of PCNL is directly related to an optimal access tract. The majority of stones in the pelvis and mid or lower calyces can be easily reached via a subcostal puncture. However, access to the stones may require an upper pole approach in specific conditions. The indications for a supracostal approach are complex staghorns, upper calyceal stones, upper ureteral stones, multiple calculi in the superior and inferior calyceal groups, and stones in anatomically unusual kidneys.[2] Access through a superior calyx provides a straight tract along the axis of the kidney, and it is associated with excellent visualization of the upper and lower calyces, the pelvis, and the ureteropelvic junction. This ability to operate along the long axis of the kidney causes less torque of the rigid nephroscope, thereby reducing the chances of excessive bleeding. Despite the high success rates, a major concern in supracostal PCNL is the potential for injury to the pleura or lung.[3]

When the supracostal approach is performed, the risk of pneumothorax or pleural effusion requiring drainage is 4% to 12%.[4] In the Kekre *et al*[5] study on the 102 cases using the supracostal approach, hydrothorax was found in 10 patients. Sukumar *et al*[2] suggested that in the case of nephrostomy access between the 11th and 12th ribs, 9.1% of patients present fluid accumulation within the pleural space. Jun-Ou and Lojanapiwat[6] reported 44 standard supracostal PCNLs compared with 39 tubeless supracostal PCNLs. They found that pleural complications were 9.6% and 9.3% with the standard and tubeless supracostal approach, respectively. Munver *at al*[7] found that punctures above the 11th rib have a 16-fold greater risk of intrathoracic complications than the supracostal 12th rib access and a 46-fold greater risk than subcostal access. However, Finelli and Honey[13] stated that the risk of pulmonary injury with 10th intercostal access is not as high as predicted by radiologic studies provided the puncture is done with the patient in full expiration. Mousavi-Bahar *et al*[3] reviewed their complications from supracostal punctures for PCNL in 123 patients, and pneumothorax was found in only 3 cases (2.4%). Similarly, Muzrakchi and coworkers[14] reported complications of PCNL during supracostal 12th rib and supracostal 11th rib access; only 2 patients had minor chest complications in this study.

We observed hydrothorax in 2 cases (5.1%) in group 2, but none of these patients needed intercostal drainage. The low incidence of pleural complications in our cases probably is attributable to our practice of making the puncture lateral to the midscapular line. Anatomically, an intercostal puncture passes through skin, subcutaneous tissue, latissimus dorsi, intercostal muscles, diaphragm, and kidney through the Gerota's fascia. The parietal pleura is usually reflected obliquely at the midpoint of the 12th rib posteriorly, and in full expiration, the visceral pleura does not reach the level of the midpoint of the 12th rib. Consequently, an intercostal access is made in the lower half of the intercostal space in full expiration, requiring coordination with an anesthetist to control respiration. Overall, the occurrence of pulmonary complications in our series was comparable with prior series.[2–7] Using a working sheath of adequate size during PCNL via the supracostal approach may prevent pleural complications. We believe that it is important to keep a low pressure within the irrigation system during PCNL to minimize the possibility of fluid entering the pleural space. Other potential complications noted in supracostal access include injury to the solid organs (liver, spleen, and lung) and intercostal vessels. We did not observe these problems in this study.

Fever is reported in up to 32% of cases after PCNL in the literature.[10] Transient fever was seen in

20 patients (8.2%), which resolved with conservative treatment in our study. All of the patients with febrile episodes in the postoperative period had negative urine cultures. The mean drop in hemoglobin was 1.88 ± 1.2 g/dL (range, 0.2–4.8 g/dL), and 25 patients (10.2%) required blood transfusion. Urinary leakage from nephrostomy tract continued for more than 2 days in 9 patients (3.7%), and they were managed by a double-J stent insertion. The stone-free rate was 86.8% in group 1 and 84.6% in group 2 after 1 session of PCNL. Auxiliary procedures consisting of URS and SWL were required in 14 cases. After the auxiliary procedures, stone-free rates increased to 92.6% in group 1 and 89.7% in group 2. Our results are comparable with former supracostal PCNL series.[2–7] Although operative time, complications, and Clavien score were higher in group 1, the difference was not statistically significant.

A flexible nephroscope and/or holmium YAG laser was used for the stone that could not be reached with the rigid instrument in our study. By using a flexible nephroscope, the surgeon is able to reach portions of the collecting system that might not have been reached with a rigid instrument. This allows for careful inspection of the renal collecting system during PCNL.

Tefekli *et al*[11] retrospectively applied the Clavien system to their series of 811 PCNLs and reported an overall complication rate of 29.2%. Although most cases were grade II, 9.4% of cases involved a grade-III complication requiring surgical or radiologic intervention. Similarly, de la Rosetta *et al*[12] retrospectively applied the Clavien system to their series of 244 PCNLs and reported an overall complication rate of 43.8%. We applied this classification to stratify recording of complications in patients undergoing supracostal PCNL at our institution. Overall, 74 cases (30.4%) had complications, of which the majority (23.8%) were Clavien grades I and II. Fifteen cases (6.1%) required surgical or radiologic intervention (grade III), 1 case had Clavien grade IVa, and there were no grade-IVb or grade-V complications.

Conclusions

Percutaneous access via the 10th and 11th intercostal space is safe and effective with an acceptable complication rate in the treatment of renal stones and should be attempted in selected cases. The modified Clavien system provides a standardized grading system for complications of PCNL. Complications may be managed with conservative measures in most cases.

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