

Supracostal access for miniaturized percutaneous nephrolithotomy: comparison of supracostal and infracostal approaches

Faruk Ozgor¹ · Abdulkadir Tepeler² · Ismail Basibuyuk³ · Onur Kucuktopcu¹ · Yunus Kayali³ · Fatih Yanaral¹ · Murat Binbay¹

Received: 7 January 2017 / Accepted: 20 March 2017 / Published online: 30 March 2017
© Springer-Verlag Berlin Heidelberg 2017

Abstract In this study, we aimed to evaluate the efficiency and safety of supracostal and subcostal approaches during miniaturized percutaneous nephrolithotomy (mPNL). In two tertiary academic centers, we retrospectively analyzed the charts of patients who had undergone mPNL between January 2011 and June 2015 for the treatment of renal stones. Enrolled in the study were 49 patients who had access through the supracostal area (Group 1) and, to serve as controls, 49 patients who were accessed through the subcostal area (Group 2). To avoid potential bias between the groups, the patients were retrospectively matched one-on-one with respect to age, gender, body mass index, ASA score, and size and number of stones. The presence of upper calyx stones and distorted lower calyx anatomy were the most common reasons for performing supracostal access (57.1 and 28.6%, respectively). Access through 11–12 intercostal space was performed in 46 patients (93.9%), and the other three supracostal accesses (6.1%) were performed through the 10–11 intercostal area. The complication rates were 14.3% in Group 1 and 16.3% in Group 2 ($p=0.952$). Final stone-free status had increased to 89.8 and 87.8% in Groups 1 and 2, respectively ($p=0.942$). Our study demonstrated that mPNL resulted in acceptable stone-free rates whether accessed through either the supracostal or subcostal areas. Moreover, the

supracostal approach with mPNL had no negative effect on any intraoperative and postoperative parameters, nor did it increase complication rates.

Keywords Hemothorax · Intercostal access · MiniPNL · Percutaneous nephrolithotomy · Pneumothorax · Supracostal

Abbreviations

| | |
|-------|------------------------------|
| BMI | Body mass index |
| CT | Computed tomography |
| IVP | Intravenous pyelography |
| KUB | Kidney–ureter–bladder |
| PNL | Percutaneous nephrolithotomy |
| SWL | Shock wave lithotripsy |
| f-URS | Flexible ureterorenoscopy |
| UTI | Urinary tract infection |

Introduction

Percutaneous nephrolithotomy (PNL) is a safe and effective treatment option in the management of renal stones [1]. During PNL, achieving non-traumatic access to the appropriate calyx is one of the most important parts of the procedure. In the majority of cases, urologists prefer subcostal access to avoid potential pulmonary complications such as hydrothorax, hemothorax, and reno-pleural fistula. Supracostal access, however, allows better visualization of the upper pole, ureteropelvic junction, proximal ureter, and lower pole. Moreover, the increased ability to manipulate the nephroscope along the long axis of the kidney minimizes torque maneuvers [2].

With advancements in technology, smaller diameter instruments have been developed for PNL. Miniaturized

✉ Faruk Ozgor
md.farukozgor@yahoo.com

¹ Department of Urology, Haseki Teaching and Research Hospital, Millet Street, Fatih, Istanbul, Turkey

² Department of Urology, Sen Jorj Austria Hospital, Beyoglu, Istanbul, Turkey

³ Department of Urology, Faculty of Medicine, Bezmialem Vakif University, Istanbul, Turkey

instruments with an access diameter of 14F–20F enable a procedure called miniaturized percutaneous nephrolithotomy (mPNL) [3]. Using smaller caliber instruments has reduced perioperative bleeding, blood transfusion rates, and hospitalization periods as well as analgesia requirements [4, 5].

Although many studies have been published about mPNL's success and morbidity, none have compared supracostal and subcostal approaches with miniaturized instruments. In this study, we aimed to evaluate the efficiency and safety of supracostal and subcostal approaches during mPNL.

Materials and methods

In two tertiary academic centers, the charts of patients who were treated with mPNL between January 2011 and June 2015 were retrospectively analyzed. Of the total of 744 patients who had had mPNL, 49 who received supracostal area access were enrolled into the study as Group 1, with a control group of 49 patients who were accessed through the subcostal area (Group 2). To minimize the bias related to the lack of randomization in this observational study, Group 2 patients were selected using propensity score matching, by balancing a range of covariate patient- and stone-related parameters in the groups. Matching variables included age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) score, and size and number of stones. Exclusion criteria were: patients under 18 years of age, those with renal anomalies or skeletal abnormalities, patients who had active pulmonary or pleural disease, and those who had had procedures that required multiple access.

A detailed medical history was obtained for every patient, and physical examinations were performed. Renal stone characteristics were preoperatively evaluated using intravenous pyelography (IVP) and/or abdominal computerized tomography (CT). The indication for supracostal access was noted. Prior to surgery, all patients had sterile urine cultures and each had signed an informed consent form.

Surgical technique

Under general anesthesia, a 5-Fr ureteral catheter was placed and contrast media was used to visualize the pelvicalyceal system, while the patient was in the prone position. Access was obtained using an 18-G percutaneous access needle under the C-armed fluoroscopy unit. Supracostal puncture was always performed during full expiration, achieved with the assistance of the anesthesiologist. The puncture was performed slightly above the upper and

lateral half of the rib to protect the intercostal vessels. Dilatation was performed using Amplatz dilators and a 16 or 20 Fr Amplatz sheath was placed. A 12-Fr or 17-Fr nephroscope (Karl Storz, Germany) was used for nephroscopy. Fragmentation was performed using a laser lithotripter and stones were extracted by graspers or baskets. The surgery was finalized after insertion of a nephrostomy tube under fluoroscopy. Operation time was calculated from the beginning of the access procedure until placement of the nephrostomy tube. At the end of each procedure, the patient was evaluated for equal air flow on both sides of the chest, and oxygen saturation was checked by the anesthesiologist. For all PNL procedures with supracostal access, a chest X-ray was routinely taken before discharge from the hospital.

Operation success was assessed with a kidney–ureter–bladder radiogram on the first postoperative day. In follow-up, stone-free rates were re-evaluated in an outpatient setting in the third postoperative month with a non-contrast computerized tomography (CT) scan. The procedure was deemed as successful if complete stone clearance was achieved or if residual fragments were <2 mm in size. Complications were classified according to the Clavien system [6].

During statistical analyses, values were evaluated as numbers, means, percentages, and intervals. Propensity score matching (balancing a range of covariate patient- and stone-related parameters in the two groups) minimized any bias caused by the lack of randomization in this observational study. Numbers and percentages were compared using the Chi square test. Before comparing means of values, the values were evaluated for homogeneity. All of those variables were heterogeneously distributed and comparison of mean was performed using the Mann–Whitney *U* test.

Results

According to the study design, the preoperative characteristics of gender, age, mean BMI, and mean ASA score were similar between the two groups ($p=0.828$, $p=0.204$, $p=0.880$, and $p=0.280$, respectively). The mean stone size was 27.1 mm in Group 1 and 27.5 mm in Group 2 ($p=0.952$). The patients' preoperative characteristics are summarized in Table 1.

The presence of upper calyx stone and distorted lower calyx anatomy was the most common reasons for achieving supracostal access (57.1 and 28.6%, respectively). Access through the supracostal area was also performed in the four patients who had high-located kidneys. Indications for supracostal access are listed in Table 2.

Table 1 Comparison of preoperative demographics of patients

| | Group 1 | Group 2 | <i>p</i> |
|-------------------------------|-----------|-----------|----------|
| <i>N</i> | 49 | 49 | |
| Gender (male /female) | 33/16 | 34/15 | 0.828 |
| Mean age (years) | 42±15 | 38±16 | 0.204 |
| Mean BMI (kg/m ²) | 27±5 | 28±8 | 0.880 |
| Mean ASA score | 1.2±0.7 | 1.3±0.5 | 0.280 |
| Mean stone size (mm) | 27.1±11.3 | 27.5±11.1 | 0.952 |
| Degree of hydronephrosis | | | |
| None | 4 | 0 | 0.124 |
| Mild (grade 1–2) | 43 | 47 | |
| Severe (grade 3–4) | 2 | 2 | |

BMI body mass index, *ASA score* American Society of Anesthesiologists score

Table 2 Indications for intercostal access

| | Group 1 |
|-------------------------|---------|
| Upper calyx stone | 28 |
| Distorted lower calyx | 14 |
| Proximal ureter stone | 1 |
| Presence of retrocolon | 2 |
| High location of kidney | 4 |

Access through the 11–12 intercostal space was performed in 46 of the Group 1 patients (93.9%), and the other three (6.1%) were performed through the 10–11 intercostal area. None required access above the 10th rib. The most common access site was the upper pole in Group 1 and the lower pole in Group 2. As expected, the difference of access site was statistically significant ($p < 0.001$), yet the mean operation time and the mean fluoroscopy screening time were similar between the groups ($p = 0.443$ and $p = 0.444$, respectively). There was also no significant difference between the groups regarding hospitalization time ($p = 0.843$) (Table 3).

The complication rates were 14.3% in Group 1 and 16.3% in Group 2 ($p = 0.952$); however, most of the complications did not require surgical manipulation. Transient hematuria occurred in two patients in Group 1 and in one patient in Group 2 (Clavien 1). Renal colic was seen in one patient in each group (Clavien 1). Blood transfusion was not required in any of the patients (Clavien 2). Post-operative urinary tract infection (UTI) that required antibiotic therapy change (Clavien 2) occurred in one patient in Group 1 and in two Group 2 patients. Due to persistent leakage of urine after removal of the nephrostomy tube, a JJ stent was inserted in each of two patients in Group 1 (one patient with local anesthesia and the other under general anesthesia) and in three patients in Group 2 (one with local

anesthesia and the two others under general anesthesia). We observed no pulmonary complication in either group, whether atelectasis, hydrothorax, hemothorax, or renopleural fistula (Table 3).

The stone-free rates following mPNL through the supracostal and subcostal areas were 75.5 and 73.5%, respectively ($p = 0.917$). Spontaneous passage of residual fragments occurred in four patients in Group 1 and three patients in Group 2. Additional procedures such as SWL, f-URS, and mPNL were carried out in six patients in Group 1 and in seven patients in Group 2. The final stone-free status was 89.8 and 87.8% in Groups 1 and 2, respectively ($p = 0.942$) (Table 3).

Discussion

The upper part of the kidney lies against the posterior part of the 11th and 12th ribs and adjacent to the parietal pleura, which attaches to the posterior part of the 12th rib on the mid-scapular line. The pleura located superior on the ribs courses laterally, whereas the visceral pleura stays at the level of the 12th rib during deep inspiration and moves to the level of the 8th rib during expiration [7]. Due to these anatomical features, supracostal puncture may traverse the pleural space and lead to pulmonary complications.

To avoid pulmonary complications, several techniques have been described for supracostal access. The puncture location is recommended to be lateral side of the mid-scapular line, with respect to the anatomical structure of the pleura. Full expiration during puncture elevates the visceral pleura and lungs. After gaining successful access, deep inspiration is used for downward displacement of the kidney [8]. Maintaining low-pressure irrigation during the procedure may help to reduce fluid leakage from the access sheath, and minimizes the risk of extravasation and pleural effusion. Puncture just below the ribs should be avoided to protect intercostal vessels and reduce hemorrhagic complications [9].

The intercostal space, through which access is performed, has been related with pulmonary complications. Following the conventional PNL (cPNL), Munver et al. experienced pulmonary complications of 7.1 and 23.1% after supra 12th and supra 11th rib access, respectively [10]. The authors concluded that access through 10–11 intercostal area was associated with a 16-fold increase in pulmonary complications compared with 11–12 intercostal area access, and a 46-fold increase in complications compared with subcostal access. Similarly, Shaban et al. reported a 33.3% pulmonary complication rate after cPNL with supra 11th rib access, but no pulmonary complications with supra 12th rib access [11]. In the present study, we observed no pulmonary complications in patients

Table 3 Intraoperative and postoperative data of Groups 1 and 2

| | Group1 | Group 2 | <i>p</i> |
|---|------------|------------|----------|
| Access location | | | |
| Lower pole | 2 | 42 | <0.001 |
| Middle pole | 3 | 6 | |
| Upper pole | 44 | 1 | |
| Mean operation time (min) | 107 ± 46 | 114 ± 44 | 0.443 |
| Mean fluoroscopy time (minutes) | 4.7 ± 4.3 | 5.4 ± 4.7 | 0.444 |
| Mean hospitalization time (days) | 2.9 ± 2.3 | 3.1 ± 1.5 | 0.843 |
| Mean hemoglobin drop (g/dl) | 1.4 ± 1.1 | 1.0 ± 0.9 | 0.192 |
| Postoperative complications | 7 (14.3%) | 8 (16.3%) | 0.952 |
| Grade 1 | 3 | 2 | |
| Grade 2 | | | |
| UTI | 1 | 2 | |
| Transfusion requirement | 1 | 1 | |
| Grade 3a | | | |
| Postoperative JJ insertion without anesthesia | 1 | 1 | |
| Grade 3b | | | |
| Postoperative JJ insertion with anesthesia | 1 | 2 | |
| Stone-free status | | | |
| Stone-free | 37 (75.5%) | 36 (73.5%) | 0.917 |
| Residual fragment | 12 (%24.5) | 13 (26.5%) | |
| Additional procedures | | | |
| Spontane passage | 4 | 3 | 0.951 |
| SWL | 3 | 3 | |
| f-URS | 2 | 3 | |
| mPNL | 1 | 1 | |
| Stone-free status after additional procedures | 44 (89.8%) | 43 (87.8%) | 0.942 |

UTI urinary tract infection

with supracostal access above the 11th and 12th ribs. We emphasize that the use of smaller caliber instruments was associated with lesser pleural and lung damage.

Previous reports have demonstrated that blood loss was reduced in mPNL compared with cPNL. Cheng et al. reported blood transfusion rates of 1.4 and 10.4% following mPNL and cPNL, respectively [12]. However, both upper pole access and supracostal area access were associated with higher risk of hemorrhagic complications. Munver et al. stated that supracostal access was significantly related with higher blood loss during cPNL compared with subcostal access [10]. Until now, none of the studies of mPNL have discussed hemorrhagic complications in mPNL with supracostal access. In our study, blood transfusion was required for one patient in each group and our transfusion rate of 2.1% was in accordance with what has been reported in the literature. As noted earlier, smaller diameter parenchymal damage during access procedures and more gentle manipulation with miniaturized instruments resulted in less bleeding during mPNL. In addition, intercostal vessels are potential bleeding sites and are located just below the ribs [9]. The distance of the intercostal area is short in some

patients and use of smaller sized instruments may result in reduced risk of vessel injury.

Stone-free rates following PNL have been reported in a wide range. Lojanapiwat et al. demonstrated that supracostal and subcostal approaches provided similar success rates after cPNL [13]. On the other hand, Lang et al. reported significantly higher success rates in patients with supracostal access following cPNL [14]. None of the studies that investigated mPNL outcomes have discussed the effect of the supracostal approach on mPNL success. In this study, we achieved 75.5 and 73.5% stone-free rates in Groups 1 and 2, respectively, after a single mPNL session. Following additional procedures, stone-free rates were increased to 89.8 and 87.8% in Groups 1 and 2, respectively. Our stone-free rates in both groups were comparable with other studies in the literature [3, 12].

In the literature, the effect of the supracostal approach on operation time is variable. In Lang's study, their cPNL operation time was significantly shorter with the supracostal approach than with the subcostal approach, and they emphasized that the shorter route with the supracostal approach was the main reason for the reduction in

operation time [14]. In contrast, Lojapiwat et al. found no significant difference in operation time between the two approaches in patients with similar preoperative characteristics, although a statistical trend in favor of the supracostal approach was observed [13]. In the present study, operation time was shorter in patients who underwent mPNL with supracostal access; however, the difference was not statistically significant.

Most urologists prefer to evaluate possible thoracic complications with postoperative chest radiography, as we performed in the present study. However, Bjurlin et al. experienced two thoracic complications among 214 patients following cPNL, and recommended performing postoperative chest radiography only in symptomatic patients [15]. In addition, Ogan et al. compared sensitivity of chest radiography and CT imaging to identify hydrothorax after cPNL in 100 patients. The authors diagnosed hydrothorax in 8 and 38 patients with chest radiography and CT imaging, respectively. In addition, they noted that seven of the eight cases diagnosed with chest radiography were symptomatic [16]. In our study, we observed no pulmonary complications following mPNL in 49 cases, leading us to believe that routine chest radiography following mPNL is of questionable value. Exploring its requirement or even its advisability after mPNL could be a worthwhile focus of further study.

Although this paper is the first to specifically investigate the differences between supra- and subcostal access during mPNL, we are aware of the limitations of the retrospective and non-randomized nature of our study, besides the relatively small number of patients. Furthermore, operations were performed by different surgeons in two different centers, which may have influenced the outcomes, although they had completed their learning curves. Finally, we did not evaluate patient quality of life and cost of procedures following mPNL with supracostal and subcostal approaches, which may be the possible subject of other research.

In conclusion, our study demonstrated that mPNL with both supracostal access and subcostal access achieved acceptable stone-free rates. Moreover, the supracostal approach with mPNL did not negatively affect any intraoperative and postoperative parameters, and did not increase the complication rate. Our findings could be supported by further prospective, randomized studies with a larger patient volume.

Author contributions Ozgor F.—Project development and manuscript writing. Yanaral F., Ozgor F.—Data analyzing. Tepeler A.—Manuscript editing. Basibuyuk I., Kayali Y.—Data collection. Kucuktopcu O.—Manuscript editing. Tepeler A.—Data collection and data management. Yanaral F., Kayali Y.—Data management. Binbay M.—Project development and manuscript editing.

Compliance with ethical standards

Conflict of interest None.

Ethical standards Informed consent was obtained preoperatively from all of our patients which were included in our study.

References

1. Mirheydar HS, Palazzi KL, Derweesh IH, et al (2013) Percutaneous nephrolithotomy use is increasing in the United States: an analysis of trends and complications. *Endourol* 27:979–983
2. Raza A, Moussa S, Smith G et al (2008) Upper pole puncture in percutaneous nephrolithotomy: a retrospective review of treatment, safety and efficacy. *BJU Int* 101:599–602
3. Mishra S, Sharma R, Garg C et al (2011) Prospective comparative study of mini perc and standard PNL for treatment of 1 to 2 cm size renal stone. *BJU Int* 108:896–899
4. Turna B, Nazli O, Demiryoguran S, Mammadov R, Cal C (2007) Percutaneous nephrolithotomy: variables that influence hemorrhage. *Urology* 269:603–607
5. El-Nahas AR, Shokeir AA, El-Assmy AM et al (2007) Post-percutaneous nephrolithotomy extensive hemorrhage: a study of risk factors. *J Urol* 177:576–579
6. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 240:205–213
7. Gupta R, Kumar A, Kapoor R et al (2002) Prospective evaluation of safety and efficacy of the supracostal approach for percutaneous nephrolithotomy. *BJU Int* 90:809–813
8. Radecka E, Brehmer M, Holmgren K et al (2003) Complications associated with percutaneous nephrolithotripsy: Supra-versus subcostal access. *Acta Radiol* 44:447–451
9. McAllister M, Lim K, Torrey R et al (2011) Intercostal vessels and nerves are at risk for injury during supracostal percutaneous nephrostolithotomy. *J Urol* 185:329–334
10. Munver R, Delvecchio FC, Newman GE et al (2001) Critical analysis of supracostal access for percutaneous renal surgery. *J Urol* 166:1242–1246
11. Shaban A, Kodera A, El Ghoneimy MN et al (2008) Safety and efficacy of supracostal access in percutaneous renal surgery. *J Endourol* 22:29–34
12. Cheng F, Yu W, Zhang X et al (2010) Minimally invasive tract in percutaneous nephrolithotomy for renal stones. *J Endourol* 24:1579–1582
13. Lojanapiwat B, Prasopsuk S (2006) Upper pole access for percutaneous nephrolithotomy: comparison of supracostal and infracostal approaches. *J Endourol* 20:391–395
14. Lang E, Thomas R, Davis R et al (2009) Risks, advantages, and complications of intercostal vs subcostal approach for percutaneous nephrolithotripsy. *Urology* 74:751–755
15. Bjurlin MA, O’Grady T, Kim R, Jordan MD, Goble SM, Hollowel MP (2012) Is routine postoperative chest radiography needed after percutaneous nephrolithotomy? *Urology* 79:791–795
16. Ogan K, Corwin TS, Smith T et al (2003) Sensitivity of chest fluoroscopy compared with chest CT and chest radiography for diagnosing hydropneumothorax in association with percutaneous nephrostolithotomy. *Urology* 62:988–992