World Journal of Urology (2019) 37:1429–1433
https://doi.org/10.1007/s00345-018-2518-x

ORIGINAL ARTICLE

# Supracostal access tubeless percutaneous nephrolithotomy: minimizing complications

**Michael W. Sourial[1] · Nathaly Francois[1] · Geoffrey N. Box[1] · Bodo E. Knudsen[1]**

Received: 9 July 2018 / Accepted: 3 October 2018 / Published online: 9 October 2018


## Abstract

**Introduction and objective** Supracostal access in percutaneous nephrolithotomy (PCNL) may be avoided due to concern for thoracic complications. The objective of the study is to report the safety and efficacy of supracostal access utilizing a tubeless (stent only) PCNL technique.

**Patients and methods** Retrospective review of perioperative outcomes of 70 patients (76 renal units) who underwent a supracostal tubeless PCNL. No nephrostomy tubes were left. All patients had a 7F ureteral stent and Foley catheter placed. The nephrostomy sheath was removed with the patient held in end-expiration, and the incision closed.

**Results** Median (IQR) age was 62 (48.3–67) years. Median stone size was 20 × 21 mm, and 14 (18%) patients had complete staghorn stones. The upper calyx was the site of access in 52 (68.4%) cases. Access was above the 12th and 11th rib in 63 (83%) and 12 (16%) cases, respectively. Median (IQR) length of stay was 30 (28–32) hours. Fifty (68.5%) patients had no residual fragments (< 2 mm) on postoperative imaging. Eight (11%) patients underwent an ancillary procedure (7 URS and 1 ESWL), with an additional seven patients becoming stone free after this procedure (78%). Thoracic complications occurred in two (2.6%) patients: one small pneumothorax, and one pleural effusion, both managed conservatively. Other complications occurred in nine patients (11.8%): bleeding requiring transfusion (1), fever (4), urinary retention (2), and syncope (2).

**Conclusion** Compared to historical controls, our approach to upper tract PCNL utilizing a nephrostomy tube-free approach resulted in an overall low thoracic complication rate and facilitated hospital discharge.

**Keywords** Percutaneous nephrolithotomy · Stent · Pneumothorax · Urinary calculi

## Introduction

Percutaneous nephrolithotomy (PCNL) remains the first-line treatment of choice for large > 2.0 cm renal stones and complex stones [1–3]. While the surgical technique has evolved since it was first described by Fernström and Johansson in 1976, the basic principle remains the same with establishing a percutaneous tract into the kidney to facilitate the removal of stones. The location of the tract may be driven by a number of factors including the size and location of the stone, a supine or prone approach, and other patient factors including the position of the kidney, the location of adjacent organs, and the position of the diaphragm. Establishing access into a posterior upper pole of the kidney has some inherent advantages as the length of the tract into the posterior upper pole is usually relatively short due to the natural lie and angle of the kidney [4, 5]. Establishing access into the upper pole and maneuvering within the collecting system is somewhat analogous to working downhill. One is able to maneuver effectively, often even into the lower pole, without having to put excessive torque on the nephroscope [6, 7]. However, access into the upper pole has been associated with a higher rate of complications in some reports. When access is established above the 12th rib, the risk of chest complications has been reported as approximately 10% and when the access is above the 11th rib, it may be as high as 25% [8–12]. Complications can include pneumothorax, hydrothorax, and hemothorax as well as nephropleural fistula.

Nephrostomy tubes are often placed at the completion of a PCNL to drain the renal unit, monitor for bleeding, and to help gain re-entry in the advent of a second-look nephroscopy. Other exit strategies have evolved including a

✉ Michael W. Sourial
Michael.sourial@osumc.edu

[1] Department of Urology, The Ohio State University Wexner Medical Center, 915 Olentangy River Road, Columbus, OH 43212, USA

"tubeless" approach where an internal ureteral stent is placed in lieu of a nephrostomy tube. Several studies have shown advantages with pain control, length of stay, and costs by utilizing this approach [13–17], while others have argued that traditional nephrostomy tubes remain the better option [18, 19].

In an effort to reduce the risk of upper tract complications after supracostal access, we began placing ureteral stents and not placing nephrostomy tubes during PCNL at our institution. This ensures adequate drainage of the renal unit and potentially allows closure of small pleural violations, instead of holding them open with a nephrostomy tube. We are now presenting our experience with this technique and report our outcomes. Only a few studies have looked at the tubeless approach in patients necessitating a supracostal access [12, 20, 21]. The objective of the study is to report the safety and efficacy of supracostal access utilizing a tubeless (stent only) PCNL technique.

## Patients and methods

### Patient selection and evaluation

This is a retrospective review of perioperative and postoperative outcomes of patients who underwent a supracostal tubeless PCNL by two urologists (BK or GB) at our center (Institutional Review Board #2016H0268). Between July 2010 and October 2016, the procedure was performed with supracostal access on 76 renal units in 70 patients. All patients underwent a non-contrast CT prior to the surgery. Access was obtained by the urologist in all cases, using an 18-G needle (Cook Medical, Bloomington, IN) aimed at the calyx of interest, and advanced at end-expiration when the kidney was immobile under fluoroscopic guidance. The tract was dilated using a Bard (Bard Medical, Covington, GA) 30F balloon (30 ATM) and the 30F nephrostomy sheath placed over the balloon. PCNL was then performed as previously reported using a conventional 24F rigid nephroscope [22]. The ShockPulse-SE (Olympus, Center Valley, PA) was the most commonly used lithotripter. No nephrostomy tubes were left and all patients had a 7F ureteral stent and Foley catheter placed. The nephrostomy sheath was removed at the completion of the procedure with the patient held in end-expiration, and the incision closed with an absorbable subcutaneous suture and Dermabond topical adhesive (Ethicon, Cincinnati, OH).

A chest radiograph was obtained in the recovery unit to evaluate for thoracic complications. The Foley catheter was removed on postoperative day one, and the patient discharged if they were successful with a voiding trial, had adequate pain control on oral analgesics, and no other complications were evident. If the patient failed a voiding trial, then they were discharged with a Foley catheter and returned to the clinic for a voiding trial 3–5 days later. The patient is followed postoperatively approximately 7–10 days after the procedure with a KUB X-ray and has stent removed by cystoscopy under local anesthesia if there is no indication for a second-look procedure (ex. significant residual stone fragments, infection stones, patient preference). Ancillary procedures were generally planned after 1 week, before the stent was removed. Patients then returned in 3 months with follow-up renal imaging (KUB, renal ultrasound, or CT scan).

### Data

Patient demographic (age, gender, BMI, previous stone event, anatomic renal abnormalities, ASA score, stone size, position, and laterality) and perioperative (site and number of percutaneous access, length of stay, stone-free status, ancillary procedures, and complications) were abstracted from the database. Stone size was measured using the largest axial and coronal diameter. In patients with multiple stones, the sum of the individual stone diameters was reported. Full staghorn was defined as occupying at least 80% of the entire pelvicalyceal system. Partial staghorn was defined as a stone occupying part of the renal pelvis and at least two calyces. Stone-free status was defined as no residual fragments greater than, or equal to, 2 mm on postoperative imaging. All calcifications seen on postoperative imaging were included in the determination of stone-free rates, and may have included pre-existing nephrocalcinosis or intraparenchymal stones, which may have impacted our stone-free rates. This methodology is similar to that used by Emmott et al. who reported a 55% true stone-free rate after PCNL [23].

### Objectives

The primary objective of the study was to report the perioperative thoracic complications. Secondary objectives were to report overall complications, length of stay, and stone-free rates.

## Results

The baseline patient and stone characteristics are summarized in Table 1. The upper, inter, and lower pole was the site of access in 52 (68.4%), 17 (22.4%), and 7 (9.2%) cases, respectively. The access was above the 12th, 11th, and 10th rib in 63 (82.9%), 12 (15.8%), and 1 (1.3%) cases, respectively. Six patients (8.6%) underwent bilateral supracostal tubeless PCNL: three simultaneously and three staged. One patient (1.3%) required one additional access

**Table 1** Baseline patient characteristics

| Characteristic | |
|---|---|
| Gender, male, *n* (%) | 30 (43) |
| Age (years), median (IQR) | 62 (48.3–67) |
| Body mass index (kg/m$^2$), median (IQR) | 32.9 (27.7–39.1) |
| ASA score, *n* (%) | |
| 1–2 | 28 (40) |
| 3–4 | 42 (60) |
| Previous stone event, *n* (%) | 49 (70) |
| Anatomic abnormality (ex. horseshoe kidney, stone in calyceal diverticulum, concomitant UPJO, bifid system, etc.), *n* (%) | 15 (20) |
| Stone size (mm), median (IQR)/(range) | |
| Axial | 20 (16–25.5)/(8–54) |
| Coronal | 21 (16–32)/(8–91) |
| Full staghorn, *n* (%) | 14 (18) |
| Partial staghorn, *n* (%) | 13 (17) |

tract. One patient (1.3%) had a concomitant ureteropelvic junction obstruction that was treated simultaneously with endopyelotomy, and four patients (5.3%) had stones in the calyceal diverticula—all of which were balloon dilated and one fulgurated. Calcium oxalate monohydrate and infectious stone (magnesium-ammonium-phosphate or carbonate apatite stones) were the most common types of stones, occurring in 25 (33%) and 15 (20%) cases, respectively. The median (IQR) length of hospital stay was 30 h (28–32). All patients who did not have any complications were discharged on postoperative day one.

Postoperative renal imaging was available in 73 cases (96%) and consisted of CT, KUB and US, KUB alone, and US alone in 14 (19%), 25 (34%), 30 (41%), and 4 (5.4%) cases, respectively. Imaging occurred at a median (IQR) of 65 days (9–115) post-PCNL. Of those cases, 50 (68.5%) were stone free. The median (IQR) residual fragment size was 6 mm (5–10). Eight patients (11%) underwent an ancillary procedure (7 ureteroscopy, 1 shockwave lithotripsy), with an additional seven patients becoming stone free after this procedure (78%).

Thoracic complications occurred in two (2.6%) cases: one small pneumothorax that resolved with conservative management (access was above the 10th rib), and one symptomatic ipsilateral pleural effusion requiring thoracocentesis (access was above the 12th rib). Other complications occurred in nine cases (11.8%), which included bleeding requiring transfusion (1), fever (4) of which only one case had confirmed bacteremia, urinary retention (2), and syncope (2) [Clavien–Dindo classification: Clavien grade 1 complications: 8 (10.5%); Clavien grade 2 complications: 2 (2.6%); Clavien grade 3a complication: 1 (1.3%)]. Perioperative outcomes are summarized in Table 2.

**Table 2** Operative outcomes

| Outcome | *n* (%) |
|---|---|
| Access site | |
| Upper | 52 (68.4%) |
| Interpolar | 17 (22.4%) |
| Lower | 7 (9.2%) |
| Access site | |
| Above the 12th rib | 63 (82.9%) |
| Above the 11th rib | 12 (15.8%) |
| Above the 10th rib | 1 (1.3%) |
| Thoracic complications | 2 (2.6) |
| Pneumothorax | 1 (1.3) |
| Hydrothorax | 1 (1.3) |
| Overall complications | 9 (11.8) |
| Bleeding requiring transfusion | 1 (1.3) |
| Fever | 4 (5.3) |
| Urinary retention | 2 (2.6) |
| Syncope | 2 (2.6) |
| Length of stay (h), median (IQR) | 30 (28–32) |
| Stone-free rate (after initial PCNL) | 50 (68.5) |
| Ancillary procedures | 8 (11) |
| Stone-free rate (post-ancillary procedure) | 57 (78) |

## Discussion

Percutaneous nephrolithotomy is the preferred surgical treatment option for large (> 2 cm) or complex stone burden [1, 2]. An upper calyx access often allows for a more in-line visualization of the renal pelvis, lower pole, and ureter. This avoids excessive torque to the kidney during stone removal and potentially allows for easier access to the ureter and a higher stone-free rate. The upper calyx

may be accessed via a supracostal or an infracostal approach. The supracostal approach has been avoided due to the fear of thoracic complications, with only 16.7% of all PCNL procedures performed via a supracostal access as reported in the CROES study [8].

Several series have looked at thoracic complications with supracostal access. Munver et al. compared 202 cases of infracostal PCNL to 98 cases of supracostal PCNL [24]. The overall complication rate was 4.5% for the infracostal group, compared to 16.3% for the supracostal group. The thoracic complication rate for the supracostal group was 7.1%. Similarly, Lojanapiwat et al. compared 294 infracostal PCNL to 170 cases of supracostal PCNL [4]. The rate of hydrothorax was 1.4% for the infracostal group, compared to 15.3% for the supracostal group. Our thoracic complication rate for our series of 2.6% compares very favorably with the thoracic complication rates reported in these studies.

Studies that evaluated tubeless PCNL in patients with a supracostal access are summarized in Table 3. Shah et al. compared the outcomes of 72 patients having undergone a supracostal tubeless PCNL to a historical cohort of similar patients having undergone PCNL with a nephrostomy tube [20]. Thoracic complications were seen in two (2.8%) patients in the tubeless group. Jun-Ou and Lojanapiwat reported their outcomes on 52 cases of standard PCNL with a nephrostomy tube compared to 43 cases of supracostal tubeless PCNL using an externalized 6F ureteral catheter that was removed along with the Foley catheter 48 h postoperatively [21]. Thoracic complications were similar in both groups (9.6% vs 9.3% for the tubeless PCNL group), with only one patient in the control group requiring intercostal drainage. Duty et al. reported the outcomes of a retrospective cohort study on 54 cases of supracostal tubeless PCNL compared to 284 standard PCNL with a nephrostomy tube [12]. They had a higher rate of chest complications in the tubeless group (22.2%) compared to the nephrostomy group (10.9%). The chest complications necessitating intervention were also higher in the tubeless group (9.3% vs 4.4% in the nephrostomy group), although this was not statistically significant. The reason for the higher complication rate in the tubeless group was not elucidated. The overall complication rate was similar in both groups (27.8% tubeless group vs 25.8% nephrostomy group). Korokovic and colleagues reported a case of an outpatient bilateral supracostal tubeless PCNL for staghorn calculi performed on a 35-year-old female, who was discharged less than 3 h following the procedure [25].

**Table 3** Series looking at supracostal tubeless PCNL outcomes

| Series | *n* | Thoracic complications (%) | Overall complications (%) | Length of stay (h) | Stone-free rate (%) |
|---|---|---|---|---|---|
| Shah et al. [20] | 72 | 2.8 | 11.1 | 34.1 | 90.27 |
| Jun-Ou and Lojanapiwat [21] | 43 | 9.3 | n/a | 82.8 | 90.7 |
| Duty et al. [12] | 54 | 22.2 | 27.8 | 60 | 81.5 |
| Current series | 76 | 2.6 | 11.8 | 30 | 78 |

In the current series, our thoracic (2.6%) and overall (11.8%) complication rates were low and compared favorably to previously published series. One patient presented on postoperative day 10 with dyspnea and pleuritic chest pain, and was found to have an ipsilateral moderate pleural effusion. Access was obtained above the 12th rib, and the postoperative chest radiograph in the recovery unit was normal. After three unsuccessful attempts at thoracocentesis, she was managed conservatively and this resolved with time. The second thoracic complication was an asymptomatic, small pneumothorax that was diagnosed on postoperative chest X-ray (access obtained above the 10th rib). This was an oxygen-dependent, chronic obstructive pulmonary disease patient. She was managed conservatively and this resolved on postoperative day 2. The low rate of thoracic complication is thought to be due to two main factors. Firstly, we remove the access sheath with the patient held at end-expiration by anesthesia, which should reduce the possibility of a hydrothorax or pneumothorax due to maximal intrapleural pressures, analogous to chest tube removal [26]. Secondly, the 7F JJ stent along with a Foley catheter ensures adequate drainage of the renal unit and potentially allows closure of small pleural violations rather than holding them open with a nephrostomy tube. The stone-free rate was slightly less than that of other series, possibly due to our definition of having no fragments $\geq 2$ mm, and the complexity of stone cases being treated at our tertiary referral center.

There are alternative strategies to avoid thoracic complications. Making use of flexible instruments (adding flexible nephroscopy and/or ureteroscopy) through a subcostal access has been shown to improve stone-free rates and reduce the need for secondary procedures [27]. The supine positioning in PCNL may also be an option, which allows for a wider angle between the lower and upper pole calyx axes, due to a more lateral lower pole tract. The upper pole calyx was approached using a rigid nephroscope (through a lower pole access) in 80% of patients positioned supine, compared to only 20% of patients positioned prone [28].

Limitations of our study include its retrospective nature and lack of a defined control group. However, this study population represented a change of practice pattern at our institution from leaving nephrostomy tubes after supracostal PCNL to a tubeless (stent only) approach. This was in part driven by having had several delayed hydrothoraces develop

after nephrostomy tube removal with the prior approach. While postoperative imaging was not standardized per protocol in this retrospective study, the majority of patients did have follow-up imaging with either a KUB and renal ultrasound or a low-dose non-contrast CT. All calcifications seen on postoperative imaging were included in the determination of stone-free rates and may have included pre-existing nephrocalcinosis or intraparenchymal stones, which may have falsely lowered the stone-free rate. The decision regarding imaging modality postoperatively was most often driven by stone composition. This is to our knowledge the largest single-center series to date looking exclusively at supracostal tubeless PCNL, and one that demonstrates the lowest rate of thoracic complications with our technique. Future larger, prospective supracostal PCNL studies should aim to compare the effect of various exit strategies on thoracic and overall complications.

## Conclusion

Compared to historical controls, our approach to supracostal PCNL utilizing a nephrostomy tube-free approach resulted in a low thoracic and overall complication rate, and facilitated hospital discharge.

**Funding** None.

### Compliance with ethical standards

**Conflict of interest** No competing financial interests exist.

## References

1. Assimos D, Krambeck A, Miller NL et al (2016) Surgical management of stones: American Urological Association/Endourological Society guideline, part I. J Urol 196:1153–1160
2. Assimos D, Krambeck A, Miller NL et al (2016) Surgical management of stones: American Urological Association/Endourological Society Guideline, part II. J Urol 196:1161–1169
3. Türk C, Petřík A, Sarica K et al (2016) EAU guidelines on interventional treatment for urolithiasis. Eur Urol 69:475–482
4. Lojanapiwat B, Prasopsuk S (2006) Upper-pole access for percutaneous nephrolithotomy: comparison of supracostal and infracostal approaches. J Endourol 20:491–494
5. Pedro RN, Netto NR (2009) Upper-pole access for percutaneous nephrolithotomy. J Endourol 23:1645–1647
6. 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
7. Tefekli A, Esen T, Olbert PJ et al (2013) Isolated upper pole access in percutaneous nephrolithotomy: a large-scale analysis from the CROES percutaneous nephrolithotomy global study. J Urol 189:568–573
8. de la Rosette J, Assimos D, Desai M et al (2011) The clinical research office of the endourological society percutaneous nephrolithotomy global study: indications, complications, and outcomes in 5803 patients. J Endourol 25:11–17
9. Soucy F, Ko R, Duvdevani M, Nott L, Denstedt JD, Razvi H (2009) Percutaneous nephrolithotomy for staghorn calculi: a single center's experience over 15 years. J Endourol 23:1669–1673
10. Duvdevani M, Razvi H, Sofer M et al (2007) Third prize: contemporary percutaneous nephrolithotripsy: 1585 procedures in 1338 consecutive patients. J Endourol 21:824–829
11. Olvera-Posada D, Tailly T, Alenezi H et al (2015) Risk factors for postoperative complications of percutaneous nephrolithotomy at a tertiary referral center. J Urol 194:1646–1651
12. Duty B, Conlin M, Wagner M, Bayne A, Adams G, Fuchs E (2013) Supracostal tubeless percutaneous nephrolithotomy: a retrospective cohort study. J Endourol 27:294–297
13. Yang RM, Bellman GC (2004) Tubeless percutaneous renal surgery in obese patients. Urology. 63:1036–1040 **(discussion 1040–1031)**
14. Shah HN, Kausik VB, Hegde SS, Shah JN, Bansal MB (2005) Safety and efficacy of bilateral simultaneous tubeless percutaneous nephrolithotomy. Urology 66:500–504
15. Aghamir SM, Hosseini SR, Gooran S (2004) Totally tubeless percutaneous nephrolithotomy. J Endourol 18:647–648
16. Bellman GC, Davidoff R, Candela J, Gerspach J, Kurtz S, Stout L (1997) Tubeless percutaneous renal surgery. J Urol 157:1578–1582
17. Choi SW, Kim KS, Kim JH et al (2014) Totally tubeless versus standard percutaneous nephrolithotomy for renal stones: analysis of clinical outcomes and cost. J Endourol 28:1487–1494
18. Zhao PT, Hoenig DM, Smith AD, Okeke Z (2016) A randomized controlled comparison of nephrostomy drainage vs ureteral stent following percutaneous nephrolithotomy using the Wisconsin StoneQOL. J Endourol 30:1275–1284
19. Kim SC, Tinmouth WW, Kuo RL, Paterson RF, Lingeman JE (2005) Using and choosing a nephrostomy tube after percutaneous nephrolithotomy for large or complex stone disease: a treatment strategy. J Endourol 19:348–352
20. Shah HN, Shah H, Hegde SS et al (2006) Safety and efficacy of supracostal access in tubeless percutaneous nephrolithotomy. J Endourol 20:1016–1021
21. Jun-Ou J, Lojanapiwat B (2010) Supracostal access: does it affect tubeless percutaneous nephrolithotomy efficacy and safety? Int Braz J Urol 36:171–176
22. Ko R, Soucy F, Denstedt JD, Razvi H (2008) Percutaneous nephrolithotomy made easier: a practical guide, tips and tricks. BJU Int 101:535–539
23. Emmott AS, Brotherhood HL, Paterson RF, Lange D, Chew BH (2018) Complications, re-intervention rates, and natural history of residual stone fragments after percutaneous nephrolithotomy. J Endourol 32:28–32
24. Munver R, Delvecchio FC, Newman GE, Preminger GM (2001) Critical analysis of supracostal access for percutaneous renal surgery. J Urol 166:1242–1246
25. Kokorovic A, Wilson JW, Beiko D (2014) Outpatient bilateral supracostal tubeless percutaneous nephrolithotomy for staghorn calculi. Can Urol Assoc J 8:E273–E275
26. Satoh Y (2016) Management of chest drainage tubes after lung surgery. Gen Thorac Cardiovasc Surg 64:305–308
27. Cracco CM, Knoll T, Liatsikos EN et al (2017) Rigid-only versus combined rigid and flexible percutaneous nephrolithotomy: a systematic review. Minerva Urol Nefrol 69:330–341
28. Sofer M, Giusti G, Proietti S et al (2016) Upper calyx approachability through a lower calyx access for prone versus supine percutaneous nephrolithotomy. J Urol 195:377–382