Upper pole urologist-obtained percutaneous renal access for PCNL is safe and efficacious

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PATEL AP, BUI D, PATTARAS J, OGAN K. Upper pole urologist-obtained percutaneous renal access for PCNL is safe and efficacious. *Can J Urol* 2017; 24(2):8754-8758.

Introduction: *Interventional radiologist may be hesitant to obtain upper pole access for percutaneous nephrolithotomy (PCNL) due to a higher complication rate. Renal access gained by urologists may achieve higher stone-free rates with similar complication rates. We evaluate our institution's contemporary results of percutaneous renal access in the upper pole for nephrolithotomy by urologists, which we believe both safe and efficacious.*
Materials and methods: *This retrospective chart review included all PCNL's performed by fellowship-trained endourologists from 2003 to 2014 at a single institution. Inclusion criteria included patients in which renal access was obtained by the urologist via the upper pole for PCNL. Stone-free status was determined by either KUB or CT scan on POD #1. Patients without stones visible on KUB or less than 4 mm on CT were considered stone-free.*
Results: *A total of 144 patients obtained upper pole access for PCNL. There were a total of 53 (37%%) staghorn calculi, of which 35 (66%) were partial staghorn stones. Renal access was obtained above 11th rib in 12.5% (n = 18), between the 11th and 12th rib in 57.6% (n = 83), subcostal in 14.6% (n = 21) and undetermined in the rest. Complications were seen in 18 (12.5%) of patients. Hydropneumothorax requiring chest tube was seen in 8 (5.6%) patients. Postoperative imaging confirmed 93 (64.5%) patients stone-free, and 35 (24.3%) required a second look PCNL.*
Conclusions: *Our experience with upper pole percutaneous renal access for nephrolithotomy has shown that it has an acceptable complication risk. It should be a part of an endourologist's armamentarium that operate on large burden, complex stones or ureteral pathology.*

Key Words: renal access, percutaneous, supracostal, nephrolithotomy

Introduction

Percutaneous nephrolithotomy (PCNL) is recommended as first-line therapy in patients with staghorn calculi or a total renal stone burden greater than 20 mm.[1,2] Renal access gained by a urologist compared to an interventional radiologist may achieve higher stone-free rates with similar complication rates.[3] Access location is determined by numerous factors such as stone size, stone location, intra-renal anatomy, kidney location, and ultimately surgeon experience.

Accepted for publication January 2017

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The kidneys lie on the quadratus lumborum and psoas muscle with the lower pole tilting forward at a 30 degree angle. Therefore, the lower pole has a longer skin-to-caliceal distance than the upper pole, and its angle to the uretero-pelvic junction can make access down the ureter difficult. Conversely, upper pole renal access provides a shorter skin-to-caliceal distance and a straighter access to the proximal ureter. However, these advantages are associated with higher complications rates due to the upper pole's intimate relationship with the lung pleura and diaphragm. Supracostal access has demonstrated higher complications rates including hydropneumothorax, pain, and hemorrhage.[4,5]

We discuss our institution's contemporary results of urologist-obtained percutaneous renal access in the upper pole for nephrolithotomy. We believe that urologist-obtained upper pole access for PCNL is both safe and efficacious.

Materials and methods

We performed an institutional review board-approved retrospective chart review of all PCNLs performed by two endourology fellowship trained urologists from 1/2003 to 8/2014. The inclusion criteria included patients in which renal access was obtained by the urologist via the upper pole for subsequent nephrolithotomy. Preoperative stone size was determined by the largest one dimension on either KUB or CT scan. We used the AUA definition of partial and complete staghorn as defined by a branched stone that occurs in part but not all, or the entire collecting system.[1]

All our procedures were performed in the prone split-leg position. Flexible prone cystoscopy was performed and a 260 cm Bentson (Cook Medical, Bloomington, IN, USA) wire was passed under fluoroscopic guidance into the kidney. Over this, a ureteropelvic junction (UPJ) occlusion balloon catheter (Cook Medical, Bloomington, IN, USA) was advanced to the UPJ, and an air nephrostogram was performed to identify the caliceal system. Air rather than contrast was used since it preferentially fills the posterior calyces. A 22-Fr council-tip catheter was placed into the bladder over the occlusion catheter. The patient was then rotated 15-20 degrees away from the surgeon bringing the posterior calyx into the anterior/posterior orientation. With the patient's breath held in full expiration, an 18 gauge Chiba needle (Cook Medical, Bloomington, IN, USA) was then inserted in a bulls-eye fashion under fluoroscopic guidance (C-arm in anterior/posterior plane) into the selected upper pole calyx. The C-arm was then rotated 30-45 degrees to the lateral plane to determine depth of insertion. Return of urine or air signified entry into the collecting system. A glide-wire was passed down the ureter into the bladder and exchanged for a Sensor (Boston Scientific, Natick, MA, USA) wire. An 8-10 Fr coaxial dilator was passed over the wire, and an Amplatz super-stiff wire (Boston Scientific, Natick, MA, USA) was passed down into the bladder as well for 2-wire access. An Ultraxx (Cook Medical, Bloomington, IN, USA) balloon dilator was passed over the wire and the tract was dilated to 20 atm water under fluoroscopic guidance, Figure 1. A 30-Fr sheath was then passed over the balloon with the distal tip positioned in the upper pole calyx. A Cyberwand (Gyrus ACMI, Southborough, MA, USA) ultrasonic lithotrite was used to complete the nephrolithotomy portion of the case. Flexible nephroscopy and stone extraction was performed following lithotripsy to remove any remaining stones. At the conclusion of the case, a 22 Fr council-tipped catheter was passed into the renal pelvis over a 6-Fr Dretler single-J stent. Postop imaging included a chest x-ray in the PACU, and either a KUB or non-contrast abdomen/pelvis CT on postoperative day (POD) #1.

Variables analyzed included age, gender, BMI, ASA, operative time, rib level, initial stone size, change in hemoglobin (Hgb), length of stay (LOS), and postop complications. Stone-free status was determined by either KUB or CT scan on POD #1. Patients without stones visible on KUB or stones less than 4 mm on CT were considered stone free. The Clavien-Dindo classification scale was used to grade postop complications.

Results

A total of 144 renal units were percutaneously accessed via the upper pole for subsequent nephrolithotomy.

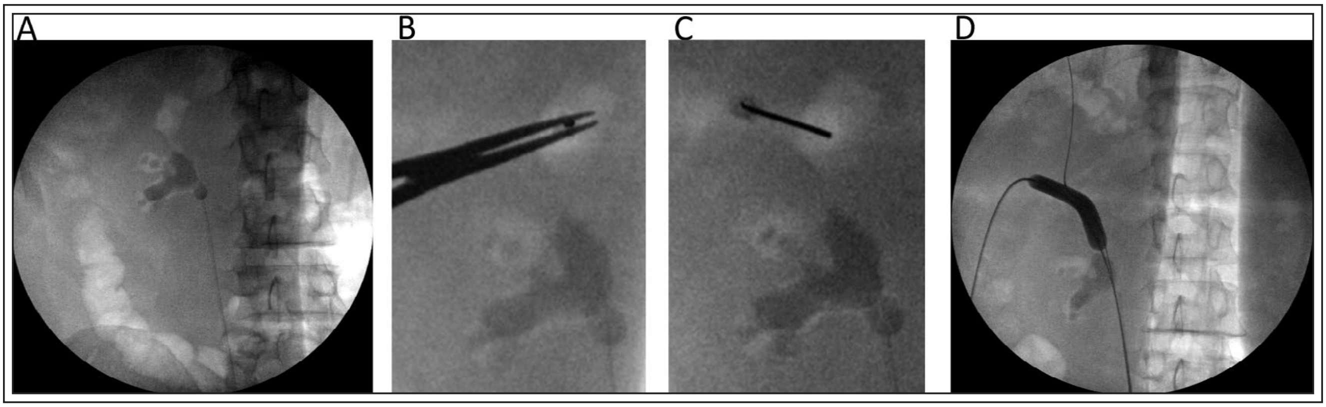

Figure 1. Obtaining renal access under fluoroscopy. **(A)** Air nephrogram to define the posterior calyceal anatomy. **(B)** "Bulls-Eye" technique at upper posterior calyx. **(C)** Needle advanced with fluoroscopy arm at 90 degreed in a vertical position. **(D)** Dilate and position sheath.

The mean age of our patients was 53 years (19-79), and 65% of our patients were female. The average BMI was 29.7 kg/m^2 (15.8-57.4) with 40% of patients being obese (BMI ≥ 30) and 11% morbidly obese (BMI ≥ 40). Our cohort had a median ASA score of 3. There were 35 partial staghorn and 18 complete staghorn calculi. The average stone size of non-staghorn stones was 3.2 cm (1-6.4) based upon the maximum dimension, Table 1.

Access was above the 11th rib in 12.5% (18), between the 11th and 12th rib in 57.6% (83), subcostal in 14.5% (21) of cases, and unable to be determined in 15.3% (22). Mean surgical time was 160 min (55-330) and average change in Hgb on POD #1 was -1.8 gm/dL (-0.6 to -6.2). Median hospital LOS was 1 days (1-17). The overall stone-free rate on POD #1 was 64.5%. In our cohort, 60% patients received postop CT's, and 40% received KUBs. Of those, 56% and 82% of the CT's and KUB's were stone free, respectively. Thirty-five (24%) patients subsequently underwent a second look procedure for residual fragments. All patients had a PCNL as a second look except for one who underwent a retrograde ureteroscopy second look. Twenty-five second look PCNLs were within the same hospital stay, and 10 were done during a separate hospital admission. A patient with an encrusted retained ureteral stent and another with a 4 cm calculus in a caliceal diverticulum underwent a second look PCNL and tertiary ureteroscopy, Table 2.

TABLE 1. **Cohort demographics**

	Total patients n = 144
Age, mean (range)	52.7 yrs (19-79)
Gender, n% (total)	
Male	35.4% (51)
Female	65.6% (93)
Body mass index, mean (range)	29.7 kg/m^2 (15.8-57.4)
ASA, median	3
Access, n% (total)	
Supra-11th rib	12.5% (18)
Supra-12th rib	57.6% (83)
Subcostal	14.5% (21)
Unknown	15.3% (22)
Non-staghorn stone size, mean (range)	3.2 cm (1-6.4)
Complete staghorn, n% (total)	12.5% (18)
Partial staghorn, n% (total)	24.3% (35)

TABLE 2. **Results**

	Total patients n = 144
Length of stay, median (range)	1 day (1-17)
OR time, mean (range)	160 min (55-330)
Hemoglobin change, mean (range)	-1.8 gm/dL (-0.6 to -6.2)
POD #1 stone-free rate n% (total)	64.5% (93)
Second look rate, n% (total)	24.3% (35)
Major complications, n% (total)	12.5% (18)
Blood transfusions, n% (total)	3.5% (5)
Hydropneumothorax, n% (total)	5.6% (8)
Supra 11th rib, total	17% (3)
Between 11th & 12th rib, total	6% (5)
Subcostal, total	0% (0)
Unknown, total	0% (0)

Clavien grade ≥ 3 complications were found in 15 (10%) cases, including 8 (5.6%) patients developing hydropneumothorax requiring chest tube decompression. Hydropneumothorax based on puncture location was as follows—above the 11th rib in 17% (3/18), between 11th and 12th rib in 6% (5/83), subcostal in 0% (0/21) and unknown 0% (0/22) for a cumulative rate of 5.6% (8/144). Of these, three patients had supra-11th rib access, and the remaining five were between the 11th and 12th rib. The remaining major complications were postop sepsis requiring ICU admission (4, 2.8%), a non-ST elevation myocardial infarction that resulted in a cardiac catheterization and stent placement, one ureteral obstruction requiring stent placement, and a narcotic overdose necessitating ICU admission. Additionally, five patients (3.5%) required blood transfusions (Clavien grade 2). There were no mortalities.

Discussion

Access is arguably the single most important step for safe and successful stone-free PCNL. Upper pole percutaneous renal access for nephrolithotomy provides excellent access with rigid instruments to most calyces, renal pelvis, and ureter. Its short skin-to-caliceal distance minimizes torque on the kidney while providing mobility.

At first look, our POD #1 stone-free rate of 64.5% and a 24.3% second look rate may seem discouraging. Factors affecting our success rate include: 37% of stones were classified as staghorn calculi, an obese population (mean BMI 30 kg/m^2), and patients with multiple comorbidities (mean ASA 3). Also, 60% of our postoperative imaging was done via CT imaging. The sensitivity of CT to detect residual fragments (RF) was close to 100% compared to less than 50% for KUB.[6] Tefekli et al[7] on behalf of the CROES PCNL group reported on 403 patients undergoing PCNL via an upper access and found a stone-free rate of 77.1%. However, in this study the staghorn rate was only 21.7% and type of postoperative imaging was not defined (plain x-ray, ultrasound, or CT). These studies demonstrated a higher detection rate of RF > 4 mm on CT compared to KUB.[6]

The technical advantages of upper pole access are offset with the increased rate of complications, specifically hydropneumothorax. In an international multi-center study, the Clinical Research Office of the Endourological Society (CROES) found that upper pole access for PCNL had an overall hydropneumothorax rate of 5.8%.[7] This mirrors our own experiences with a similar hydropneumothorax rate of 5.6%. When broken down by location, we experienced a 17% supra 11th rib, 6% between 11th and 12th rib, and 0% subcostal hydropneumothorax rate. Of note, all but one patient had normal post-anesthesia care unit (PACU) chest x-rays. The remainder became symptomatic upon removal of the percutaneous nephrostomy tube prior to discharge. All patients were treated with a chest tube with one patient requiring a video assisted thoracoscopy for management of a loculated empyema. Our blood transfusion rate was 3.5% compared to 7.3% and 4.0% for the CROES upper pole and lower pole cohort respectively.[7] We did not have any organ injuries or mortalities in our group.

Munver et al retrospective reviewed their supracostal access.[4] A total of 300 nephrostomy tracts were placed intraoperatively over a 6 year duration. Ninety-nine (33%) of these were through the upper pole calyx. Out of the 300, 202 (67.4%) tracts were subcostal, and 98 (32.6%) were supracostal tracts. The supracostal tracts were further stratified to supra-11th rib (26.5%) and supra-12th rib (73.5%), however these were not specific to any calyx. The complication rate was 16.3% for a supracostal tract when compared to a 4.5% for a subcostal tract. Upon closer examination of their supracostal access, their supra-11th rib access had a 34.6% complication rate, but a supra-12th rib had a 9.7% complication rate. Their cohort had eight hydropneumothoraces (2.7%), with seven of them with supracostal access (6 supra-11th rib, 1 supra-12th rib).

The international experience for upper pole percutaneous nephrolithotomy has been favorable. Raza et al from the United Kingdom reports a 31% overall complication rate with a 3% pneumothorax rate out of 66 upper calyx punctures, but these were not divided into supracostal and subcostal.[8] From Egypt, Shaban et al had two thoracic complications (hydrothorax, renopleural fistula) out of a cohort of 30 patients who underwent a supracostal approach.[9] In India, Gupta et al performed 62 supracostal PCNLs. They had an 11% chest complication rate, but again this was not stratified to a rib-specific site.[10]

There are many advantages to urology directed upper pole access. Miller et al states that upper pole access is indicated in staghorn calculi, large upper pole stone burden, antegrade endopyelotomy, large and/or impacted proximal ureteral calculi, upper pole caliceal diverticulum, complex lower pole calculi, and horseshoe kidney.[11] Unquestionably, upper pole access is superior for UPJ and ureteral access. Anecdotally, we have had significant reluctance of Interventional Radiology to perform upper pole access hindering our ability to access parts of the kidney. One idea to reduce hydropneumothorax is to place the patient in a prone-flex position.[12] This brings the kidney down caudally in relation to the costal spaces. Our cohort had no thoracic complications if the access was subcostal and the hydropneumothorax rate between the 11th and 12th rib was substantially less than supra-11th rib access.

Our study has multiple limitations. It is a retrospective study that looks at a relatively small cohort. All the procedures were performed by two endourology surgeons within our institution. The evolution in technique including different postoperative imaging modalities and second-look criteria can make interpreting the data difficult. A prospective trial comparing upper to lower pole access would be warranted to determine if there are distinct advantages to upper pole access that justify its potentially higher complication rates.

Conclusion

Our experience with upper pole percutaneous renal access for nephrolithotomy has shown that it has an acceptable complication risk. There is an increased chance of thoracic complications. It should be a part of an endourologist's armamentarium who operate on large burden, complex stones or ureteral pathology. □

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