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Outcomes for Patients Undergoing Ambulatory Percutaneous Nephrolithotomy

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Abstract

Introduction: Multiple studies have concluded that ambulatory percutaneous nephrolithotomy (aPCNL) is safe. However, selection criteria remain vague and no investigators have assessed the practicality of using various post-procedural drainage strategies in the ambulatory setting. In this study we establish a set of inclusion and exclusion criteria for aPCNL, compare outcomes between aPCNL patients and those admitted following PCNL, and incorporate a variety of ''exit'' strategies including Double-J stent, ureteropelvic junction (UPJ) stent and totally tubeless techniques.
Methods: We developed inclusion and exclusion criteria to determine patient eligibility for aPCNL. Between January 2014 and December 2016, 52 out of 145 patients met criteria for aPCNL and 47 of these patients were ultimately discharged on the same day. Forty-seven of the remaining 98 patients who were admitted following PCNL were randomly selected as a control group. Primary outcomes included stone-free status, emergency department (ED) visits and hospital readmissions within the 6-week post-operative period. Statistical analysis was performed using Student's *t*-tests, chi square tests, and Fischer's exact tests.
Results: Both groups had similar age ($P = 0.91$), sex ($P = 0.68$), body mass index ($P = 0.91$), and stone burden ($P = 0.12$). Patients in the ambulatory group had a lower Charlson Comorbidity score (aPCNL CCS = 0.11, inpatient PCNL CCS = 0.62, $P = 0.002$). Seventy three percent of ambulatory patients and 62% of standard PCNL patients had no residual stone burden 6 weeks following PCNL ($P = 0.33$). The average residual stone fragment in our ambulatory and standard PCNL group was 3.5 and 3.2 mm, respectively. Five patients (11%) from the aPCNL group and 4 (9%) from the standard PCNL group presented to the ED ($P = 0.76$). One aPCNL (2%) and three standard PCNL (6%) patients were re-admitted to the hospital ($P = 0.62$).
Conclusions: In this study we establish specific inclusion and exclusion criteria for aPCNL. Using these criteria we then demonstrated the practicality of using various exit strategies to facilitate aPCNL. Future randomized control trials would be beneficial in confirming the safety and efficacy of aPCNL in select patients.

Keywords: percutaneous nephrolithotomy, ambulatory PCNL, nephrolithiasis

Introduction

First described in the 1970 s, percutaneous nephrolithotomy (PCNL) has become the standard of care for the removal of renal calculi >2 cm.[1,2] In the original procedure, PCNL was generally followed by placement of a nephrostomy tube. With increasing recognition of the morbidity associated with nephrostomy tubes, and in an attempt to decrease length of hospital stays, urologists have devised alternate ''exit'' strategies to the standard PCNL.[3] Use of a ureteral stent in lieu of a nephrostomy tube has been reported with success and has become increasingly common.[4–6]

Preminger et al. first reported on ambulatory PCNL (aPCNL) in five patients highlighting the technological advances of instrumentation that allowed for this early series.[7] Further streamlining of the procedure with elimination of external drainage has ushered in new interest in PCNL as an outpatient ambulatory case.[8–10] Use of a Double-J stent in lieu of external drainage has been shown to have good outcomes in well selected cases.[11,12] Possible alternatives to the Double-J ureteral stent to further facilitate aPCNL include the ureteropelvic junction (UPJ) stent and a totally tubeless approach.[13,14]

With increased interest in aPCNL the literature is expanding, yet case series remain small and standardized criteria for use of aPCNL have not been determined. As such, after reviewing our initial experience with aPCNL in January of 2014 we developed criteria to determine eligibility for same day discharge. We then prospectively tracked this new cohort and compared outcomes between those patients undergoing aPCNL to a group of standard PCNL patients during the same time period with a specific focus on emergency

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department (ED) visits, readmissions and stone free rates in the 6 week post-operative period.

Materials and Methods

Patients

Albert Einstein College of Medicine Institutional Review Board approval was obtained for the prospective maintenance of this cohort. In January 2014, we created formal criteria to determine eligibility for aPCNL (Table 1). aPCNL was defined as same day discharge with no overnight stay. Between January 2014 and January 2016, 52 of 145 patients undergoing PCNL by a single surgeon at our institution satisfied criteria for same-day discharge. Of these 52 patients, 5 remained overnight post-operatively, leaving 47 aPCNL patients. Pre-operative complete blood count, basic metabolic panel, and urine culture were performed along with non-contrast enhanced computed tomography (CT). Patients meeting inclusion criteria were actively counseled pre-operatively on the likelihood and risks and benefits of same day discharge after PCNL.

To create a contemporaneous comparison group for aPCNL, 47 patients not discharged the same day were randomly selected using Microsoft Excel's random number generator function.[15]

Percutaneous nephrolithotomy

PCNL was performed in prone position under general anesthesia. Prone flexible cystoscopy was used to place a wire retrograde and a ureteral occlusion balloon (Boston Scientific) was advanced over the wire. Percutaneous access was obtained into an appropriate calyx and a 30F Nephromax dilating balloon (Boston Scientific) was used to dilate the tract over the wire. A 26F rigid nephroscope was then inserted through the sheath. Stones were fragmented and extracted with a Swiss Lithoclast™ (Boston Scientific). Calyces were explored with flexible nephroscopy and additional fragments retrieved with a variety of baskets. Antegrade flexible ureteroscopy and nephrostogram were routinely used to assess patency of the ureter.

Table 1. Inclusion and Exclusion Criteria for Ambulatory Percutaneous Nephrolithotomy

Inclusion criteria
> 18 years of age
BMI <45 kg/m^2
Any stone size
Single access with ≤3 attempted punctures
Patient agreeable with discharge plans
Pre-Operative Exclusion Criteria
Positive urine culture within 3 weeks of surgery
Pre-operative indwelling ureteral stent or nephrostomy tube
Solitary functioning kidney
Transplant kidney
Nursing home patients
Non-mobile patients
Charlson Comorbidity Score ≥3
Intra-Operative Exclusion Criteria
Significant pelvicaliceal system perforation
Placement of traditional nephrostomy tube for drainage
Post-Operative Exclusion Criteria
Temperature >100.4 Fahrenheit
Hemodynamic instability:
Heart rate >90 beats per minute
Respiratory Rate >20 breaths per minute
Systolic blood pressure <90 mmHg or drop in systolic blood pressure >40 mmHg
> 3 g/dL drop in Hemoglobin
Transfusion of blood products
Pneumothorax or hemothorax on chest X ray
Uncontrolled nausea and vomiting
Pain not well controlled with oral analgesic
Unable to void or ambulate

Exit strategy

Exit strategies for aPCNL patients consisted of tubeless approach with a Double-J ureteral stent, totally tubeless, or use of a UPJ stent. A tubeless approach with Double-J stent was selected if there appeared to be ureteral edema or injury in the mid to distal ureter, or any time a stent was warranted for more than 3 days. A totally tubeless technique was utilized when no ureteral injury or edema was identified and if anterograde flexible ureteroscopy showed no distal ureteral stones. A UPJ stent was selectively used when the UPJ or the proximal ureter was considered edematous or traumatized but the distal ureter was patent, with technique as previously described.[13] Pressure was then held for hemostasis, followed by dressing application. Surgiflo® (Ethicon) was used on a case-by-case basis.

Post-operative course

Patients were extubated and transferred to the recovery area. They were given oral oxycodone-acetaminophen for pain control. Once awake, foley catheters were removed for a trial of void if considered for same day discharge, otherwise catheters remained until day of discharge. Routine CBC and BMP were obtained. Ambulatory patients were discharged home once ambulating, tolerating liquids orally, and once a trial of void was passed. Those with UPJ stents were instructed to pull the extraction string from their flank within 1–3 days of surgery. Patients with regular Double-J ureteral stents had them removed cystoscopically during their post-operative appointment. Routine post-operative imaging included a 4–6 week ultrasound or non-contrast CT scan.

The primary study endpoints were ED visits and readmissions within the 6 week post-operative period. Stone free status was also determined and defined both as a 3 mm residual fragment and as no residual stone burden.

Data analysis

Categorical variables were reported as numbers and percentages. Continuous variables were reported as means and standard deviations. Student's *t*-test was used to compare preoperative and postoperative hemoglobin, age, body mass index (BMI), Charlson score, stone burden and operative time between the two groups. Chi square test was used to compare sex and ethnicity between groups. Fischer's exact test was used to compare stone-free rates, readmissions and ED visits between standard and ambulatory PCNL participants. All tests were two-tailed, with a *P*-value less than 0.05 accepted for statistically significant differences.

Results

Demographics

Fifty two patients met criteria for aPCNL, and 47 of these patients underwent same day discharge. Baseline characteristics are found in Table 2. Ages between the ambulatory and standard PCNL groups were similar (ambulatory = 53.0 ± 9.8, standard = 53.3 ± 14.4, $P = 0.91$). Forty-nine percent of ambulatory patients were female, compared to 45% of standard PCNL patients ($P = 0.68$). There was no significant difference in BMI (ambulatory = 30.4 ± 5.6, standard = 30.6 ± 6.7, $P = 0.91$). Our standard PCNL cohort had higher Charlson Comorbidity scores (0.11 ± 0.4 for aPCNL *vs* 0.62 ± 1.0 for standard PCNL, $P = 0.002$).

Standard and ambulatory PCNL patients had similar stone burden (2.81 cm *vs* 2.34 cm, respectively, $P = 0.12$). The mean difference between pre- and post-operative hemoglobin was not statistically different between the two groups (ambulatory = 0.86 ± 1.47; inpatient = 1.38 ± 1.38; $P = 0.10$). Mean operative time was 15 minutes longer for patients in our standard PCNL cohort (100 minutes *vs* 115 minutes, $P = 0.10$). Five patients that met inclusion criteria for aPCNL were not discharged as they decided post-operatively to stay overnight in the hospital. All were discharged the next day and none had any post-operative complications.

Exit strategy

Table 3 highlights the exit strategies employed for both ambulatory and non-ambulatory patients. Exit strategy in the aPCNL group: Double-J stent-10patients, UPJ stent -21 patients, totally tubeless - 16 patients. Exit strategy in the inpatient PCNL group: percutaneous nephrostomy tube-4 patients, Double-J stent- 7 patients, UPJ stent- 26 patients, totally tubeless-10 patients.

In the aPCNL group, the average length of stent placement was 2.6 ± 0.5 days for UPJ stents and 18.1 ± 8.6 days for Double-J stents. In the standard PCNL group, the average length of stent placement was 2.7 ± 0.5 days for UPJ stents and 24.4 ± 17.8 days for Double-J stents.

Table 2. Demographics and Perioperative Characteristics of Ambulatory and Admitted Patients

	Ambulatory	*Inpatient*	P *value*
Age ± SD	53.0 ± 9.8	53.3 ± 14.4	0.91
Gender			0.68
Male	24	26	
Female	23	21	
BMI ± SD	30.4 ± 5.6	30.6 ± 6.7	0.91
Charlson comorbidity score ± SD	0.11 ± 0.4	0.62 ± 1.0	0.002
Mean stone size ± SD (cm)	2.34 ± 1.45	2.81 ± 1.45	0.12
Mean operative time ± SD (minutes)	100.1 ± 30.4	115.0 ± 52.4	0.10
Mean difference in pre and post operative hemoglobin ± SD (g/dL)	0.86 ± 1.47	1.38 ± 1.38	0.10

Table 3. Exit Strategies for Ambulatory and Admitted Patients

Exit strategy	*Ambulatory*	*Inpatient*
Percutaneous nephrostomy	0	4
Double-J stent	10	7
Ureteropelvic junction stent	21	26
Totally tubeless	16	10

ED visits, admissions and complications

Five (10.6%) aPCNL and four (8.5%) standard PCNL patients had an ED visit within 6 weeks ($P = 0.76$). One aPCNL and three standard PCNL patients were then admitted (Table 4). 2/5 of the aPCNL patients presented with stent discomfort on post operative day 2. Imaging confirmed stents were in place without hydronephrosis or ureteral stones and they were discharged. Another 2/5 aPCNL patients that were totally tubeless presented to the ED with flank pain. Imaging and labs were unremarkable and they were discharged after receiving adequate supportive care and hydration. The fifth aPCNL patient presented to the ED on post-operative day 3 after removing his UPJ stent with complaints of pain and subjective fever. In the ED this patient was afebrile with unremarkable labs and imaging but the patient was admitted for supportive care.

In the standard PCNL group, 2/4 patients presented to the ED with flank pain following UPJ stent removal. One had normal imaging and labs and achieved adequate pain control, and was discharged from the ED. The other also had normal imaging and labs but required a 1-day admission for pain control and supportive care. A third patient, who had a Double-J stent, presented with fever and tachycardia from a nursing home. He was treated for sepsis secondary to a pseudomonas urinary tract infection. The 4th patient, who had a Double-J stent, was re-admitted with complaints of left-sided chest pain and shortness of breath. Imaging revealed a left sided pleural effusion without evidence of pneumothorax. A temporary 8F pigtail catheter was placed by interventional radiology, which drained 900 cc of fluid. The catheter was left in place for 2 days and then removed. Chest X-rays remained clear after initial placement of the catheter and the patient was discharged 4 days after admission.

The aPCNL patients experienced a low number of complications: Four grade I Clavien dindo complications (three for analgesic administration and 1 for prescription of an antiemetic). The standard PCNL group had six grade II complications (including two transfusions and four patients needing IV antibiotics, all before discharge), and two grade III complications (chest tube placement for pleural effusion as noted above and ureteroscopic extraction of retained stent).

Table 4. Emergency Department Visits and Readmissions for Ambulatory and Admitted Patients

	Ambulatory		*Inpatient*		
	N	%	N	%	P *value*
ED visits	5	11%	4	9%	0.76
Readmissions	1	2%	3	6%	0.62

ED = emergency department.

Stone free rate

Forty aPCNL patients and 37 standard PCNL patients received post-operative imaging with CT scan or ultrasound. Of these 34 (85%) aPCNL patients (5 CT scan and 29 ultrasound) and 29 (78%) standard PCNL patients (9 CT scan and 20 ultrasound) had residual stone burden less than 3 mm ($P = 0.42$). Twenty-nine (73%) aPCNL patients (5 CT scan and 24 ultrasound) and 23 (62%) standard PCNL patients (7 CT scan and 16 ultrasound) were confirmed stone free with no residual stone burden ($P = 0.33$). Among patients with residual stones, the mean residual stone burden in our ambulatory and standard PCNL groups was 3.45 and 3.23 mm, respectively.

Discussion

PCNL with nephrostomy tube placement remains a source of high patient morbidity.[16] As a result, many investigators have sought alternate exit strategies to the standard PCNL, including a tubeless and totally tubeless approach. Bhat et al. performed a randomized control trial comparing standard PCNL with tubeless and totally tubeless PCNL and found that tubeless and totally tubeless patients required less analgesia and had hospital stays 40 hours shorter than standard PCNL patients.[17] In a systematic review and meta-analysis, Borges et al. found that length of stay decreased by 1.11 days (95% CI: 68–1.55) when using tubeless PCNL compared to standard nephrostomy tube.[18] 34% of our aPCNL group was sent home totally tubeless and 66% were sent home with a stent.

Decreased length of stay associated with these alternate exit strategies prompted various investigators to explore the possibility of aPCNL. Shahrour and Andonian reported on their initial experience of 10 patients who underwent ambulatory tubeless PCNL.[11] Similarly, Beiko and Lee and El Tabey et al. each found that aPCNL on a select group of patients was feasible.[10,12] However, these studies were limited by small patient cohorts, varying definitions of ''ambulatory'' and no comparisons to a standard PCNL cohort. A recent report by Bechis et al. compared outcomes between a group of 60 ambulatory and 37 standard PCNL patients, and showed similar complication rates, ED visits and readmissions between the two cohorts.[19] However, only 42 of the 60 ''ambulatory'' patients were discharged same day with the rest requiring an overnight admission and none of these patients were totally tubeless, an exit strategy worth investigating in an ambulatory cohort.

In this study we developed a set of inclusion and exclusion criteria for aPCNL based both on earlier clinical experience with a small cohort of aPCNL patients as well as on existing literature. In reviewing the available data we identified a set of exclusion criteria for patients not fit for aPCNL (Table 1). We excluded nursing home patients and non-mobile patients, not only due to logistical issues of social work but also because nursing home status is an independent risk factor for sepsis.[20] Similarly, we admitted patients with pre-operative ureteral stents or nephrostomy tubes for observation due to the increased risk of post-surgery sepsis.[21] We used Charlson Comorbidity Score ≥3 as part of our exclusion criteria as there is evidence that scores above three are associated with increased complications from PCNL.[22–24]

Various studies have explored the extent to which increased BMI is associated with poor post-operative outcomes. While multiple studies have found adverse surgical events more common in patients with BMIs >50, few have definitively found increased adverse events in patients with BMIs between 40 and 50.[25–27] Furthermore, Dauw et al. found no differences in post operative outcomes or adverse events in morbidly obese (BMI >50) and obese patients (25.1 < BMI <49.9) compared to those with BMI <25 undergoing standard PCNL.[28] The average BMI in our aPCNL cohort was 30.4 ± 5.6 and patients with BMIs between 35 and 45 experienced no significant differences in outcomes compared to lower BMI patients suggesting that increased BMI alone shouldn't preclude ambulatory PCNL.

Having established an aPCNL cohort, we sought to contextualize primary outcomes by comparing the group to a random selection of 47 standard PCNL patients who met exclusion criteria during the same time period and who were operated on by the same surgeon. The groups had similar baseline characteristics including age, BMI, Charlson score and stone burden (Table 2).

Both cohorts had a low incidence of ED visits and readmissions to the hospital, with 11% and 9% in the aPCNL and standard PCNL groups presenting to the ED, respectively. These findings are comparable to the limited data currently available on post-operative outcomes in patients undergoing aPCNL which report a 12% rate of ED visits and a 4% overall re-admission rate.[29] Large case series of patients undergoing standard PCNL report a 15% rate of unplanned post-operative visits.[30–32] Understanding that some of these series report larger stone volumes it does compare well to the 12.8% rate of unplanned visits (ED visits and readmissions) in our aPCNL group. Additionally, our finding of four (8.5%) clavien I complications in our ambulatory patients is also similar to the 11.1% clavien I complications in a large cohort of almost 6000 standard PCNL patients recently compiled.[33]

We acknowledge that this study has several limitations. We evaluated the safety of ambulatory PCNL but did not measure subjective patient feedback regarding urinary tract symptoms or quality of life after same day discharge. Our control group was randomly selected and had similar baseline characteristics to our ambulatory group, however the possibility for selection bias cannot be excluded as admitted patients are different from those deemed eligible for discharge by means of inclusion/exclusion criteria. In the future, choosing control patients who meet criteria for discharge but are nonetheless admitted would provide a better control group. As this is a retrospective review of a limited number of patients, a prospective randomized trial would lend further credence to the efficacy and safety of aPCNL.

Conclusions

Our study demonstrates the feasibility of performing aPCNL with modified selection criteria. We demonstrated no significant difference in subsequent ED visits and readmissions and achieved similar stone-free rates compared to patients undergoing non-ambulatory PCNL.

Author Disclosure Statement

No competing financial interests exist.

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Abbreviations Used

aPCNL = ambulatory percutaneous nephrolithotomy
BMI = body mass index
CT = computed tomography
ED = emergency department
UPJ = ureteropelvic junction