JOURNAL OF ENDOUROLOGY
Volume 32, Number 5, May 2018

Pp. 394–401
DOI: 10.1089/end.2018.0056

Outpatient Percutaneous Nephrolithotomy: The UC San Diego Health Experience

Seth K. Bechis, MD,[1] Daniel S. Han, MD,[1] Joel E. Abbott, DO,[2] Daniel D. Holst, MD,[1] Amy Alagh, MD,[3] Thomas DiPina, BA,[1] and Roger L. Sur, MD[1]

Abstract

Introduction: Outpatient percutaneous nephrolithotomy (PCNL) has been described for highly selected patients. We sought to assess the safety and feasibility of outpatient PCNL in a tertiary referral stone center *without strict patient selection criteria.*

Materials and Methods: We reviewed all PCNLs performed at our institution from September 2015 to October 2016. Of the 97 eligible cases, 60 patients underwent planned outpatient PCNL. Primary outcome was complication rate, and secondary outcome determined predictor variables of inpatient admission.

Results: Thirty-seven inpatient and 60 planned outpatient (one bilateral) PCNLs were performed with 65% and 44% American Society of Anesthesiologists (ASA) score ≥3, respectively. The 30-day overall complication rate for the inpatient and planned outpatient groups was 27% and 20%, respectively ($p=0.43$) [70% and 92% Clavien grades I–II]. Emergency department presentation within 30 days was 19% and 18% ($p=0.94$), and unplanned hospital readmission rate was 3% and 10% ($p=0.05$). The 37 inpatient PCNL patients had larger total stone burden than outpatient cases (40.7 *vs* 25.8 mm, $p=0.0014$); more often required two or more punctures into the kidney during the procedure (73% *vs* 45%, $p=0.025$); and more often had supracostal access (20% *vs* 7%, $p=0.05$). For the outpatient PCNL cohort, 72% patients were discharged same day, 28% were observed overnight for refractory symptoms or social reasons. Outpatient cohort radiographic stone-free rate by CT (no stones) was 67%.

Conclusion: Outpatient PCNL has been safely and effectively performed within our institution in moderate-sized stones almost regardless of comorbidity status. We suggest that this approach is a potential algorithmic change in centers with sufficient case volume.

Keywords: percutaneous nephrolithotomy (PCNL), ambulatory, outpatient, nephrolithiasis, outcomes

Introduction

Since its first description in 1976,[1] percutaneous nephrolithotomy (PCNL) has become the mainstay of treatment for patients with large or complex renal calculi and is the American Urological Association (AUA)-recommended approach.[2] Patients are typically admitted overnight to monitor for sepsis, acute blood loss, pain control, and urinary drainage, but it is unclear whether this practice actually improves outcomes.[3,4] As more surgical procedures are shifting toward the outpatient setting to reduce healthcare costs and maintain or improve patient safety,[5] many urologic endoscopic procedures have also made the transition. A recent study in Canada described the safety and effectiveness of PCNL in an outpatient setting for 50 patients,[6] but no large reports from the United States exist in the literature to date. Plausible explanations include the following: the earlier report represents an unreproducible outcome, publication bias limits our exposure to new results, or nonclinical healthcare system factors repress the diffusion of this practice. It is particularly interesting that U.S. PCNL remains an inpatient surgery despite the Centers for Medicare Services recent requirement for outpatient reimbursement. Despite recent financial pressures to align reimbursement with practice patterns, large cohort evidence beyond case reports is necessary to justify the movement toward outpatient PCNL. We hypothesized that our outpatient PCNL experience would reveal outcomes with acceptable complication rates. We therefore sought to assess the safety and feasibility of outpatient PCNL in a tertiary referral stone center without strict patient selection criteria. By comparing outpatient cases with inpatient cases, we secondarily

[1]Department of Urology, UC San Diego Health, La Jolla, California.
[2]Chesapeake Urology Associates, University of Maryland, Baltimore, Baltimore, Maryland.
[3]UC San Diego School of Medicine, La Jolla, California.

Table 1. Perioperative Data, Planned Inpatient *vs* Outpatient Percutaneous Nephrolithotomy

	Inpatient (n = *37*)	*Outpatient* (n = *60*)	p
Female	25 (68%)	33 (55%)	0.21
Age (years), mean	51.4 ± 2.5	54.9 ± 1.96	0.28
BMI (kg/m^2)	27.9 ± 1.5	27.8 ± 1.2	0.95
LOS (days)	3.7 ± 0.6	0.3 ± 0.5	**<0.0001**
Diabetes mellitus type 2	10 (27%)	9 (15%)	0.15
Coronary artery disease	5 (14%0	5 (8%)	0.42
Hypertension	15 (41%)	24 (40%)	0.96
Hyperlipidemia	9 (24%)	19 (32%)	0.43
Gout	2 (5%)	2 (3%)	0.64
Immunocompromised	1 (3%)	6 (10%)	0.15
ASA class			0.12
ASA 1	3 (8%)	3 (5%)	
ASA 2	10 (27%)	31 (52%)	
ASA 3	23 (62%)	25 (42%)	
ASA 4	1 (3%)	1 (2%)	
GFR-MDRD (mL/minute/1.73 m^2)	75.5	90.5	0.25
Laterality			0.60
Left	23 (62%)	38 (63%)	
Right	14 (38%)	21 (35%)	
bilateral	0 (0%)	1 (2%)	
Largest stone diameter, mm	21.7 ± 1.7	18.4 ± 1.3	0.13
Sum diameter of all stones, mm	40.7 ± 3.6	25.8 ± 2.7	**0.0014**
Hounsfield units	960 ± 58	1063 ± 47	0.17
Partial or complete staghorn	11 (31%)	10 (17%)	0.12
Encrusted stent	3 (8%)	4 (7%)	0.79
Preoperative stent in place	7 (19%)	14 (23%)	0.61
Preoperative nephrostomy in place	8 (22%)	12 (20%)	0.85
History of endoscopy	23 (62%)	37 (62%)	0.96
Renal/structural abnormalities	9 (24%)	11 (19%)	0.54
Horseshoe kidney	1 (3%)	2 (3%)	
Presence of hydronephrosis	7 (19%)	25 (43%)	**0.013**
No. of punctures			**0.025**
1 only	8 (27%)	16 (55%)	
2 or more	22 (73%)	13 (45%)	
No. of dilated access tracts			0.67
1	32 (87%)	50 (83%)	
2	5 (14%)	10 (17%)	
Access location			0.81
Upper pole	8 (22%)	10 (28%)	
Interpolar	9 (25%)	16 (44%)	
Lower pole	13 (36%)	16 (44%)	
Multiple	4 (11%)	12 (33%)	
Existing NT	2 (6%)	4 (11%)	
Above 12th rib?	7 (20%)	4 (7%)	**0.05**
Operative time (cystoscopy to close)	151 ± 9	135 ± 7	0.15
Total fluoro time (seconds)	244 ± 29	209 ± 17	0.31
EBL (mL)	200 ± 20	140 ± 10	**0.028**
Clinically stone free (all modalities)[a]	16/22 (72%)	35/36 (97%)	**0.0052**
Radiographically stone free (all modalities)[b]	9/22 (41%)	26/36 (72%)	**0.018**
Clinically stone free after staged cases[a]	16/19 (84%)	35/35 (100%)	**0.010**
Radiographically stone free after staged cases[a]	9/19 (47%)	26/35 (74%)	**0.049**
Clinically stone free (CT only)[a]	13/19 (68%)	8/9 (89%)	0.22
Radiographically stone free (CT only)[b]	7/19 (37%)	6/9 (67%)	0.14
Urinary drainage at end of case:			0.085
Double-J stent	26 (70%)	53 (88%)	
PCN	7 (19%)	5 (8%)	
Stent + PCN	4 (11%)	2 (3%)	
Preoperative laboratories	*n* = 30	*n* = 50	
Positive urine culture	17 (49%)	20 (33%)	0.14

(*continued*)

Table 1. (Continued)

	Inpatient (n = *37*)	*Outpatient* (n = *60*)	p
WBC	9.1 ± 0.53	6.8 ± 0.42	**0.0014**
Hemoglobin	12.4 ± 3.6	12.6 ± 2.8	0.71
Hematocrit	37.8 ± 3.9	37.9 ± 5.8	0.95
Creatinine	0.92 ± 0.1	1.01 ± 0.07	0.43
Postoperative laboratories	*n* = 34	*n* = 37	
Hemoglobin	10.8 ± 0.33	12.1 ± 0.32	**0.0043**
Hematocrit	33 ± 0.9	36 ± 0.9	**0.0268**
Creatinine	1.07 ± 0.09	1.02 ± 0.09	0.68
Stent externalized on string	7 (24%)	11 (20%)	0.17
When was stent removed (POD)	21 ± 4	10 ± 3	**0.0287**
Complication within 30 days?	10 (27%)	12 (20%)	0.43
Positive Ucx within 30 days	2 (5%)	6 (10%)	0.41
Positive blood culture within 30 days	0 (0%)	0 (0%)	
Fever >101°F	4 (11%)	1 (2%)	**0.049**
SIRS	3 (8%)	2 (3%)	0.31
Sepsis (bacteriuria with SIRS)	2 (5%)	2 (3%)	0.62
Blood transfusion	0 (0%)	0 (0%)	
ED visit within 30 days	7 (19%)	11 (18%)	0.94
Unplanned hospital readmission	1 (3%)	6 (10%)	0.057
ICU stay	2 (5%)	0 (0%)	**0.048**

[a]No fragments >3 mm on postoperative CT or KUB/US.
[b]No fragments of any size on postoperative CT or KUB/US.
Bold values indicate statistical significance.
ASA = American Society of Anesthesiologists; BMI = body mass index; EBL = estimated blood loss; ED = emergency department; GFR-MDRD = glomerular filtration rate-modification of diet in renal disease; KUB = kidney, ureter, and bladder radiograph; LOS = length of stay; NT = nephrostomy tube; PCN = percutaneous nephrostomy tube; POD = postoperative day; SIRS = systemic inflammatory response syndrome; Ucx = urine culture; US = ultrasound; WBC = white blood cell.

sought to identify patient and surgical case factors that could help identify which patients would be most suitable for the outpatient approach.

Materials and Methods

After institutional review board exempt status was granted (project #170796), we performed a retrospective review of all patients undergoing PCNL at our tertiary care kidney stone center from September 2015 through October 2016. In September 2015, we developed a clinical algorithm for performing outpatient PCNLs.

Patients were excluded from consideration for outpatient PCNL if they had complex medical comorbidities that required significant high-level nursing care or home providers during the perioperative period such as spina bifida, quadriplegia with limited transportation, or any patients requiring overnight observation per anesthesia such as severe obstructive apnea. Patients who were scheduled to have staged PCNLs for staghorn renal calculi or bilateral stones were also excluded for outpatient treatment. We did not exclude patients for comorbidity status such as American Society of Anesthesiologists (ASA) score or body mass index (BMI). Preoperative urinary tract infections were treated with at least a 2- to 7-day course of culture-directed antibiotics but were not excluded from consideration for outpatient PCNL. Patients with a history of recurrent infections or preplaced urinary drainage were also not excluded. Patients were counseled preoperatively that they would be discharged home after surgery if they met the following criteria: no evidence of hypovolemic shock or systemic inflammatory response syndrome (SIRS), able to void, and pain controlled with oral acetaminophen and/or narcotics. Patients were required to have adequate family or social support as well as access to a clinic or hospital should they require urgent postoperative care. All procedures were performed by a single surgeon (R.L.S.). Patients not meeting outpatient criteria were planned for overnight admission.

Technique

General anesthesia was induced and a ureteral catheter was placed with flexible cystoscopy (Olympus America, Center Valley, PA) in retrograde manner unless a nephrostomy tube was already present. The patient was then placed in the prone position and multidirectional C-arm fluoroscopy and/or ultrasonography were used to guide renal caliceal access using an 18 Ga needle.

A single dilated percutaneous access tract was created in 32 of 37 inpatient PCNLs and 50 of 60 planned outpatient PCNLs, while 2 access tracts were created in the remaining 15 renal units. Maneuvers were performed over a working guidewire with a secondary safety wire in place. Tract dilation to 30F was then performed using the NephroMax dilating balloon (Boston Scientific, Marlborough, MA), and a 27F rigid nephroscope (Karl Storz, Tuttlingen, Germany) was used in all cases. Ultrasonic or holmium laser lithotripsy was performed in all but five cases, with most using the Swiss Lithoclast device (Boston Scientific). ''Tubeless'' was defined as only a 6F double pigtail ureteral stent placed in an antegrade manner (79 cases), while an 8F nephrostomy tube was placed in 12 patients, and 6 additional patients had both stent and nephrostomy tube placed. For tubeless cases, the renal tract was closed with a hemostatic plug of thrombin-soaked gel foam.[7] In some cases, stents were left with a string in place emanating from the flank to facilitate removal

TABLE 2. PERIOPERATIVE DATA, OUTPATIENT *vs* OUTPATIENT WITH OVERNIGHT STAY

	Outpatient (n = *43*)	*Overnight* (n = *17*)	p
Female	22 (51%)	11 (65%)	0.34
Age (years), mean	54 ± 2	56 ± 4	0.65
BMI (kg/m^2)	28.2 ± 1.2	26.7 ± 2.0	0.51
Diabetes mellitus type 2	7 (16%)	2 (12%)	0.65
Coronary artery disease	5 (12%)	0 (0%)	0.06
Hypertension	18 (42%)	6 (35%)	0.64
Hyperlipidemia	9 (21%)	10 (59%)	**0.0053**
Gout	1 (2%)	1 (6%)	0.52
Immunocompromised	4 (9%)	2 (12%)	0.78
ASA class			0.35
ASA 1	1 (2%)	2 (12%)	
ASA 2	24 (56%)	7 (41%)	
ASA 3	17 (40%)	8 (47%)	
ASA 4	1 (2%)	0 (0%)	
GFR-MDRD (mL/minute/1.73 m^2)	93 ± 12	86 ± 18	0.74
Laterality			0.06
Left	25 (58%)	13 (76%)	
Right	18 (42%)	3 (18%)	
bilateral	0 (0%)	1 (6%)	
Largest stone diameter, mm	19.0 ± 1.2	17.0 ± 1.8	0.36
Sum diameter of all stones, mm	26.3 ± 2.1	24.6 ± 3.2	0.66
Hounsfield units	1074 ± 63	1038 ± 96	0.76
Partial or complete staghorn	8 (19%)	2 (13%)	0.56
Encrusted stent	4 (9%)	0 (0%)	0.10
Preoperative stent in place	11 (26%)	3 (18%)	0.50
Preoperative nephrostomy in place	9 (21%)	3 (18%)	0.77
History of endoscopy	28 (65%)	9 (53%)	0.39
Renal/structural abnormalities	7 (17%)	4 (24%)	0.57
Horseshoe kidney	1 (2%)	1 (6%)	
Presence of hydronephrosis	18 (43%)	7 (44%)	0.95
No. of punctures			0.38
1 only	6 (46%)	10 (63%)	
2 or more	7 (54%)	6 (37%)	
No. of dilated access tracts			0.90
1	36 (84%)	14 (82%)	
2	7 (16%)	3 (18%)	
Access location			0.29
Upper pole	6 (14%)	4 (24%)	
Interpolar	13 (30%)	3 (18%)	
Lower pole	10 (23%)	6 (35%)	
Multiple	8 (19%)	4 (24%)	
Existing NT	4 (9%)	0 (0%)	
Above 12th rib?	3 (7%)	1 (6%)	0.86
Operative time (cystoscopy to close)	141 ± 8	120 ± 12	0.14
Total fluoro time (seconds)	204 ± 19	221 ± 31	0.62
EBL (mL)	130 ± 10	180 ± 20	0.095
Clinically stone free (all modalities)[a]	22/23 (96%)	13/13 (100%)	0.34
Radiographically stone free (all modalities)[b]	16/23 (70%)	10/13 (77%)	0.63
Urinary drainage at end of case:			0.74
Double-J stent	38 (88%)	15 (88%)	
PCN	4 (9%)	1 (6%)	
Stent + PCN	1 (2%)	1 (6%)	
Preoperative laboratories	*n* = 34	*n* = 16	
Positive urine culture	12 (28%)	8 (47%)	0.16
WBC	7.3 ± 0.45	5.9 ± 0.66	0.087
Hemoglobin	13.0 ± 0.36	11.7 ± 0.53	**0.042**
Hematocrit	38.9 ± 1.0	35.9 ± 1.4	0.087
Creatinine	1.04 ± 0.87	0.86 ± 0.13	0.25

(*continued*)

TABLE 2. (CONTINUED)

	Outpatient (n = *43*)	*Overnight* (n = *17*)	p
Postoperative laboratories	*n* = *23*	*n* = *14*	
Hemoglobin	12.1 ± 0.44	11.8 ± 0.56	0.69
Hematocrit	36.1 ± 1.2	35.9 ± 1.5	0.94
Creatinine	1.09 ± 0.14	0.92 ± 0.16	0.44
Stent externalized on string	8 (21%)	3 (19%)	0.9
When was stent removed (POD)	11 ± 2	9 ± 2	0.65
Complication within 30 days?	8 (19%)	4 (24%)	0.67
Positive Ucx within 30 days	6 (14%)	0 (0%)	**0.039**
Positive blood culture within 30 days	0 (0%)	0 (0%)	—
Fever >101°F	1 (2%)	0 (0%)	0.41
SIRS	2 (5%)	0 (0%)	0.24
Sepsis (bacteriuria with SIRS)	2 (5%)	0 (0%)	0.24
Blood transfusion	0 (0%)	0 (0%)	—
ED visit within 30 days	8 (19%)	3 (18%)	0.93
Unplanned hospital readmission	5 (12%)	1 (6%)	0.26
ICU stay	0 (0%)	0 (0%)	—

[a]No fragments >3 mm on postoperative CT or KUB/US.
[b]No fragments of any size on postoperative CT or KUB/US.
Bold values indicate statistical significance.

postoperatively. A local intercostal nerve block and incisional injection with 30cc of 0.5% Marcaine with epinephrine were then given.

Patients were transferred to the recovery room, given analgesics (fentanyl, dilaudid, and acetaminophen) and antinausea medications (ondansetron, promethazine), and encouraged to ambulate. A chest X-ray was obtained to rule out pneumothorax. The urethral catheter was removed before discharge as long as no significant hematuria or clots were present. Patients were discharged after demonstrating ability to void, normal postoperative vital signs, and oral medication-controlled pain. Patients were given instructions to return to the emergency department should they develop refractory pain, dizziness, inability to tolerate orals, fever T > 100.6°F, or gross hematuria with clots. Patients returned for outpatient postoperative follow up in 3 to 21 days, at which time their stent or nephrostomy was removed. Postoperative imaging (noncontrast CT scan or renal ultrasound (US) with or without KUB) was performed within 4 to 8 weeks.

Data collection

Patient information collected included demographics and comorbidities. Preoperative data and intraoperative data were obtained (Tables 1 and 2). Postoperative data collected included length of stay, clinical stone-free rate (SFR) (no residual fragments greater than 3 mm on postoperative CT or US), radiographic SFR (*no* fragments seen on CT or US), and 30-day postoperative complications. We did not routinely collect postoperative blood work in the recovery room unless there was concern for sepsis or significant bleeding. If serum creatinine and hemoglobin laboratories were obtained within 30 days after surgery (72% of patients), we included that data in our analysis.

Primary and secondary outcomes

The *primary outcome* was the incidence of postoperative complications within 30 days of surgery utilizing the Clavien–Dindo classification for surgical complications (blinded grading by S.K.B. and D.H.).[8] The *secondary outcome* was a comparative analysis of planned outpatient *vs* planned inpatient PCNL to determine factors that predict allowance for outpatient PCNL. Subgroup analysis of planned outpatient PCNL patients who ultimately stayed overnight was also performed.

Statistics

Comparative statistics were performed with continuous variables expressed with mean (±standard deviation) and categorical variables expressed with proportions. Chi-squared, analysis of variance and *t*-tests were performed using univariate analysis. A type I error of alpha = 0.05 was accepted. Error of multiple testing was accounted for by Bonferroni testing. JMP Pro 13 (SAS Institute, Cary, NC) was used for statistical analysis.

Results

In total, 37 patients underwent planned inpatient PCNL and 60 patients underwent planned outpatient PCNL (61 renal units with one bilateral PCNL). Outcomes for planned outpatient groups are shown in Table 3.

Primary outcome

The 30-day overall complication rate for the inpatient and planned outpatient groups was 27% and 20%, respectively

TABLE 3. POSTOPERATIVE STATISTICS: OUTPATIENT PERCUTANEOUS NEPHROLITHOTOMY

Characteristic	n *(%)*
Outpatient discharge	43 (72)
Overnight admission	17 (28)
Nausea/pain control	7 (12)
Social reasons	6 (10
Delayed return of pulmonary function	2 (3)
Urinary retention	1 (2)
Leak from access site requiring PCN change	1 (2)

Table 4. Thirty-Day Postoperative Complications: Inpatient Percutaneous Nephrolithotomy

Clavien	*Complication* (n = *10*)	*Total*
Grade 1		
	Flank/abdominal pain	3
	Stent colic	1
	Scrotal swelling	1
Grade 2		
	Apical pneumothorax	1
	Gross hematuria	1
Grade 3a		
	None	0
Grade 3b		
	Postoperative empyema requiring decortication	1
Grade 4a		
	Sepsis/ICU	2
Grade 4b		
	None	0
ED visit		7
Flank pain		3
Gross hematuria		1
Stent colic		1
Scrotal swelling		1
Low hemoglobin, not transfused		1
Hospital readmission		1
Gross hematuria		1

($p = 0.43$). The rate of presentation to the emergency department within 30 days was 19% and 18% ($p = 0.94$), and the unplanned hospital readmission rate was 3% and 10% ($p = 0.057$), respectively. Complications and reasons for visits/readmissions are presented in Tables 4 and 5. Two of 10 inpatient complications were sepsis requiring ICU care, and one patient developed empyema requiring surgical decortication. Outpatients who went home on day of surgery did not have any serious (greater than Clavien grade 2) complications, and one patient who stayed overnight had a misplaced stent requiring a procedure to remove it (Clavien grade 3b). There was no difference in sepsis. No patients in either group received blood transfusion.

Secondary outcome

Both planned inpatient and planned outpatient cohorts were similar demographically, including ASA ≥3 score. The 37 inpatient PCNL patients were different from outpatient cases in the following domains: larger total stone burden (40.7 *vs* 25.8 mm, $p = 0.0014$); more likely to require two or more punctures into the kidney during the procedure (73% *vs* 45%, $p = 0.025$); have supracostal access; greater blood loss; and higher incidence of postoperative fevers and ICU admissions. Planned outpatients were more likely to have hydronephrosis (43% *vs* 19%, $p = 0.013$). Overall clinical SFR (after completing all staged procedures) was lower for the planned inpatient *vs* outpatient cohort, 84% *vs* 100%, respectively ($p = 0.010$). Radiographic SFR was also lower, 47% *vs* 74% ($p = 0.049$). In the inpatient cohort, 22 patients had documented postoperative imaging of which 19 were CT and 3 were US. Thirty-six patients in the outpatient cohort had documented imaging of which 9 were CT and 27 were US with or without KUB. When comparing cohorts with CT imaging only, clinical SFR was 68% *vs* 89% and radiographic SFR was 37% *vs* 67% for inpatient *vs* outpatient, respectively; these results did not reach statistical significance likely due to small sample size.

Subgroup analysis

Of the total 60 patients who underwent planned outpatient PCNL, 43 (72%) were effectively discharged on the day of surgery and 17 stayed overnight for observation. Both groups had similar preoperative and intraoperative characteristics (Table 2). Greater than 40% of both groups were ASA 3 or higher; 19% and 13% had partial staghorn stones, respectively; and 88% of each cohort were performed tubeless. Of the 17 patients who stayed overnight, 7 were kept for postanesthesia nausea or pain control and 6 for social reasons such as inability to arrange transportation (Table 3). No differences were seen in clinical SFR between cohorts, 96% *vs* 100%, respectively ($p = 0.34$).

Discussion

Patients undergoing PCNL are still generally admitted overnight and nephrostomy tubes are commonly used despite improved pain scores and shorter length of hospital stay associated with indwelling stent or ''tubeless'' procedures.[9–11] Traditionally taught risks of hematuria, ureteral obstruction, and sepsis have led to the persistence of these practices. However, a growing body of literature suggests that complication rates are no worse with the tubeless approach and even an outpatient approach may be acceptable in certain circumstances.[12] Whether overnight hospitalization improves outcomes has recently been challenged.[3]

These facts speak to the need to assess the role of outpatient tubeless PCNL. Several studies reported acceptable outcomes with outpatient PCNL performed in highly selected patients.[3,13,14] The Beiko group reported success in an updated cohort that was expanded over time to include patients with ASA scores of 3 (18% of cohort) and BMI over 35 kg/m^2.[6] They reported a high SFR, few postoperative complications, and acceptable emergency department (ED) and readmission rates. However, no peer-reviewed publications have reported outpatient PCNLs performed in the United States.

We report our initial experience performing outpatient PCNL in patients to whom we did not apply a strict selection criteria. Most patients were scheduled for planned outpatient surgery regardless of either comorbidity or history of infections or urinary drainage tubes. For example, 44% of patients for outpatient PCNL had an ASA ≥3 and nearly 20% had renal anomalies or complex anatomy, including two horseshoe kidneys and one transplant kidney (interventional radiology preplaced access). Intraoperatively, 17% of outpatient cases required more than one dilated access tract. In this series, 72% of planned outpatient cases were able to be discharged home on the same day. Furthermore, treatment outcomes were not compromised: our clinical SFR of 89% (CT only) is higher than most other reports (42%–90%).[15–20] In addition, although our radiographic SFR of 67% indicates the presence of small residual fragments in almost one-third of cases, this SFR is still greater than other reports, including a recent study of 658 PCNL patients (55%).[18,20]

Table 5. Thirty-Day Postoperative Complications: Planned Outpatient Percutaneous Nephrolithotomy (by Clavien Grade)

Same day discharge: complication (n = 8)	*Total*	*Overnight stay: complication (n = 4)*	*Total*
Grade 1		Grade 1	
Gross hematuria	1	Flank pain	2
Urinary drainage from renal access site	2		
Grade 2		Grade 2	
Pyelonephritis	1	Wound infection requiring Abx	1
Sepsis	1		
Postoperative UTI	3		
Grade 3a		Grade 3a	
None	0	None	0
Grade 3b		Grade 3b	
None	0	Misplaced stent requiring endoscopic removal	1
Grade 4		Grade 4	
None	0	None	0
ED visit	8	ED visit	**3**
Stent colic	1	Flank pain	2
Drug-related fevers	1	Wound infection	1
Pyelonephritis	1		
Sepsis	1		
Drainage from PCN site	1		
Gross hematuria	1		
Acute renal insufficiency	1		
Cellulitis of scrotum	1		
Unplanned hospital readmission	5	Unplanned hospital readmission	1
Sepsis	1	Misplaced stent requiring endoscopic removal	1
Pyelonephritis	1		
Drainage from renal access site	1		
Acute renal insufficiency	1		
Nephrostomy tube upsizing	1		

Abx = antibiotic; UTI = urinary tract infection.

Most importantly, we report reasonable adverse event outcomes with this outpatient cohort (30-day complication 20%, readmission 10%, and sepsis 3%) similar to those reported for our inpatient cohort. Published overall complication rates for inpatient PCNL are 29% to 83% with a sepsis rate of 0.9% to 4.7%.[15] Beiko et al. reported a series of 50 outpatient PCNLs with 18% Clavien I–II complications.[6] The majority of our complications were of low clinical severity (Clavien I–II).

In many ways, PCNL is similar to a renal trauma, which can be managed conservatively despite hemorrhage or significant urinary extravasation (with ureteral stenting) in the majority of cases. Our outpatient PCNL cohort experienced minimal blood loss or changes in renal function, and no patient required blood transfusion. We observed that significant renal bleeding or precursors of sepsis are apparent either in the operating room or immediately postoperatively, allowing for identification of patients requiring admission before the time that they would be discharged home.

The natural question becomes who are ideal patients for this practice? To answer this question, we performed a comparative analysis between patients scheduled for outpatient *vs* inpatient PCNL. Planned inpatient stones were >4 cm in total burden compared with planned outpatient cases 2.6 cm ($p = 0.001$). Using the number of needle access attempts ($p = 0.025$), need for supracostal access ($p = 0.05$), and lack of hydronephrosis ($p = 0.013$) as surrogates for complex anatomy, the planned inpatient cases statistically appeared more complex. These findings suggest that large stones >4 cm and complex anatomy are more ideally suited for inpatient PCNL.

To better understand why 28% of patients stayed overnight despite being scheduled for outpatient PCNL, we performed a subgroup analysis of the planned outpatient PCNL cohort and discovered no differences in preoperative or intraoperative variables. Of the 17 patients kept overnight, 11 were for nausea/pain control and 6 for social reasons (e.g., no ride home) (Table 3). In fact, review of the *entire* study cohort suggests that—other than patients with refractory symptoms or planned staged PCNL—social reasons or chronic care was the primary trigger for inpatient admission (including high-level medical care such as spina bifida, paraplegia, neurologic disorders, and those unable to perform independent decision-making). Excluding patients with poor social support, our data suggest that urologists considering outpatient PCNL for nonselected patients should be prepared to keep ~18% of patients overnight. The retrospective nature of this analysis carries known threats of systematic errors. Furthermore, applying outpatient PCNL without *a priori* explicitly, strictly adhered exclusion creates selection bias. These limitations notwithstanding, our report is the largest U.S. series of outpatient PCNL that suggests both reproducibility and feasibility. Outpatient PCNL is potentially a trifecta win for patients (quality of life), providers (work flow), and health systems (financial).

Centers that perform PCNLs less frequently might consider a graduated approach to incorporating the outpatient procedure—smaller stone volume, minimal intraoperative bleeding, shorter operative times, nonstaged PCNL, and familiarity with the tubeless approach. By no means is this report meant to be prescriptive regarding a urologist's postoperative algorithm, as the decision for inpatient admission should always rely on surgeon comfort and clinical judgment; however, our results suggest there is room for a directional movement in postoperative management of PCNL that should give consideration to outpatient care.

Conclusions

Outpatient PCNL has been safely and effectively performed within our institution almost regardless of comorbidity status in moderate-sized stones. We suggest that this approach is a potential algorithmic change in centers with sufficient case volume.

Author Disclosure Statement

No competing financial interests exist.

References

1. Fernström I, Johansson B. Percutaneous pyelolithotomy. A new extraction technique. Scand J Urol Nephrol 1976;10: 257–259.
2. Assimos D, Krambeck A, Miller NL, et al. Surgical management of stones: American Urological Association/Endourological Society Guideline, PART II. J Urol 2016;196: 1161–1169.
3. Fahmy A, Rhashad H, Algebaly O, Sameh W. Can percutaneous nephrolithotomy be performed as an outpatient procedure? Arab J Urol 2017;15:1–6.
4. Abbott JE, Davalos J. Ambulatory percutaneous nephrolithotomy: 2 year 150 case experience. WCE abstract. J Endourol 2017;31:A179.
5. Farach SM, Danielson PD, Walford NE, Harmel RP, Jr., Chandler NM. Same-day discharge after appendectomy results in cost savings and improved efficiency. Am Surg 2014;80:787–791.
6. Beiko D, Elkoushy M, Kokorovic A, Roberts G, Robb S, Andonian S. Ambulatory percutaneous nephrolithotomy: What is the rate of readmission? J Endourol 2015;29:410–414.
7. Abbott JE, Cicic A, Jump RW 3rd, Davalos JG. Hemostatic plug: Novel technique for closure of percutaneous nephrostomy tract. J Endourol 2015;29:263–269.
8. de la Rosette JJ, Opondo D, Daels FP, et al. Categorisation of complications and validation of the Clavien score for percutaneous nephrolithotomy. Eur Urol 2012;62:246–255.
9. Garofalo M, Pultrone CV, Schiavina R, et al. Tubeless procedure reduces hospitalization and pain after percutaneous nephrolithotomy: Results of a multivariable analysis. Urolithiasis 2013;41:347–353.
10. Wang J, Zhao C, Zhang C, et al. Tubeless vs standard percutaneous nephrolithotomy: A meta-analysis. BJU Int 2012;109:918–924.
11. de Cógáin MR, Krambeck AE. Advances in tubeless percutaneous nephrolithotomy and patient selection: An update. Curr Urol Rep 2013;14:130–137.
12. Preminger GM, Clayman RV, Curry T, Redman HC, Peters PC. Outpatient percutaneous nephrostolithotomy. J Urol 1986;136:355–357.
13. Beiko D, Lee L. Outpatient tubeless percutaneous nephrolithotomy: The initial case series. Can Urol Assoc J 2010;4:E86–E90.
14. Shahrour W, Andonian S. Ambulatory percutaneous nephrolithotomy: Initial series. Urology 2010;76:1288–1292.
15. de la Rosette J, Assimos D, Desai M, et al. The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study: Indications, complications, and outcomes in 5803 patients. J Endourol 2011;25:11–17.
16. Preminger GM, Assimos DG, Lingeman JE, et al. Chapter 1: AUA guideline on management of staghorn calculi: Diagnosis and treatment recommendations. J Urol 2005; 173:1991–2000.
17. El-Nahas AR, Eraky I, Shokeir AA, et al. Factors affecting stone-free rate and complications of percutaneous nephrolithotomy for treatment of staghorn stone. Urology 2012;79:1236–1241.
18. Emmott AS, Brotherhood HL, Paterson RF, Lange D, Chew BH. Complications, re-intervention rates, and natural history of residual stone fragments after percutaneous nephrolithotomy. J Endourol 2018;32:28–32.
19. Tracy CR, Gupta A, Pearle MS, et al. Calcium–phosphate content does not affect stone-free rate after percutaneous nephrolithotomy. J Urol 2012;187:169–172.
20. Park J, Hong B, Park T, et al. Effectiveness of noncontrast computed tomography in evaluation of residual stones after percutaneous nephrolithotomy. J Endourol 2007;21:684–687.

Address correspondence to:
Roger L. Sur, MD
Department of Urology
UC San Diego Health
200 Arbor Drive #8897
San Diego, CA 92103

E-mail: rlsur@ucsd.edu

Abbreviations Used

ASA = American Society of Anesthesiologists
BMI = body mass index
CT = computed tomography
PCNL = percutaneous nephrolithotomy
US = ultrasound