Postoperative events and complications of next-day stent removal following uncomplicated percutaneous nephrolithotomy compared to longer stenting: A retrospective review

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ABSTRACT

KEY MESSAGES

- In this limited, retrospective study, we did not detect a difference in postoperative events (postoperative telephone calls, complications, or ED/clinic visits) for POD1 vs. later stent removal after uncomplicated PCNL.

Introduction: Options for renal drainage after percutaneous nephrolithotomy (PCNL) vary and depend primarily on surgeon preference and case considerations. In our practice, patients traditionally returned one week postoperatively to remove the stents in the office via cystoscopy; however, following uncomplicated PCNL with no plans for second-look procedure, a ureteral stent on a tether is currently removed in tandem with the Foley catheter on postoperative day 1 (POD1) prior to patient discharge. This study compares the number of postoperative events between POD1 stent removal and their longer stented counterparts.
Methods: We conducted a retrospective chart review on all patients who had undergone PCNL at our institution from January 1, 2020 to June 31, 2021. Patient demographics, operative metrics, and postoperative events (telephone calls, emergency department [ED]/clinic visits, and complications) were recorded and compared between the two groups.
Results: A total of 243 patients were included in final analysis: 46% (n=111) had their stent removed on POD1 and 54% (n=132) had longer indwelling stent times. Baseline demographics

were similar between the two groups. Number of telephone calls (p=0.081), ED/clinic visits (p=0.093), and complications (p=0.647) were similar between groups. There were three (1.3%) unplanned second-look procedures: two (1.8%) in the POD1 stent removal group and one (0.8%, p=0.475) in the later stent removal group.
Conclusions: In this limited, retrospective study, we did not detect a difference in postoperative events or short-term complications for POD1 vs. later stent removal after uncomplicated PCNL.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is the gold standard procedure for managing large or complex uroliths.[1] Options for kidney drainage following PCNL include nephrostomy tubes, ureteral stenting, 5F ureteral catheters, or a "totally tubeless" approach, and is based primarily on surgeon preference and case considerations.[2] Studies have demonstrated improved post-operative pain and hospital stay without worse safety outcomes in patients managed with ureteral stents as opposed to nephrostomy tube after PCNL.[3-6] Indwelling stents can be removed via outpatient cystoscopy several days post-operatively, [2] however outpatient cystoscopy can be inconvenient and stents are often poorly tolerated with 78% of patients reporting urinary discomfort and over 80% of patients reporting stent-related pain affecting daily activities.[7,8] Previous studies have examined leaving the tether attached to the stent for easy removal at a later date.[7,9,10] To our knowledge, no study has been performed examining the optimal duration of indwelling ureteral stent time after PCNL. At our institution, in select patients, the ureteral stent on a tether is often removed in tandem with the Foley catheter on post-operative day one (POD1) prior to patient discharge following uncomplicated PCNL. As such, the patient is discharged "totally tubeless," which obviates the need for a return visit for stent removal.

The objective of this study was to determine whether patients who had their stent removed on POD1 after PCNL versus at a later time presented with more post-operative events (telephone calls, unplanned clinic or emergency department visits) or complications as a result of earlier stent removal compared to their longer stented counterparts.

METHODS

This was a retrospective chart review performed on patients who underwent PCNL at our institution from January 1, 2020 to June 31, 2021 (IRB # 2021H0297). All patients undergoing PCNL were evaluated for inclusion. Exclusion criteria included (i) younger than 18 years, (ii) spinal cord injury and/or presence of neurogenic bladder or with reconstructed or altered urogenital anatomy, (iii) procedures with incomplete stone clearance with a planned second procedure, (iv) patients with a nephrostomy tube or other tubes for post-operative drainage, and (v) concomitant bilateral procedures or procedures on a solitary kidney. Any of these criteria defined the PCNL procedure as "complicated" and were excluded. See Figure 1. Of note, this practice was started at our institution during the COVID-19 pandemic to minimize foot traffic for patients having to come back in person to have stents removed from their procedure. Given that patients fared well, the two surgeons who performed pcnls at our institution adopted this practice more regularly at that time.

The PCNL procedure was performed by one of two surgeons. The decision to plan for POD1 stent removal was made at the discretion of the operating surgeon at the conclusion of each case. For a stent to be removed on POD1, there had to be no unanticipated intraoperative challenges such as severely impacted stones, collecting system/ureter injury, vital sign instability, excessive bleeding during the procedure, or suspected residual fragments (visually by rigid and flexible nephroscopy, or fluoroscopically). In those instances, a stent would usually be left for a longer period of time.

For patients who were eligible for POD1 stent removal, at the completion of the procedure the surgeon places the indwelling ureteral stent in a retrograde fashion from the urethra with patient in either the prone or supine position. The stent is left on its tether and attached to the Foley catheter, allowing for easy removal of both the Foley and the stent the following morning of discharge on POD1. The patients are observed for at least two hours or until they successfully pass a void trial to ensure no issues arise after stent removal. Patients are discharged with scheduled acetaminophen, diclofenac or short course of narcotics depending on renal function, tamsulosin daily for two weeks, and stool softeners with a standardized discharge instruction handout, and follow-up in 8-12 weeks with abdominal x-ray and renal ultrasound. Baseline demographic data was collected on all patients. Operative and stone characteristics were tabulated and included patient position, length of surgery, stone burden, stone composition and Guy's stone score as previously described.[11] Stent disposition was recorded by number of days with stent in place (POD1 vs. Later stent removal). Concomitant procedures performed included ipsilateral ureteroscopy (endoscopic combined intrarenal surgery, ECIRS), cystolithalopaxy, or urethral stricture dilation.

Data on post-operative events were recorded for the 30-day period following stent removal, including patient telephone calls or electronic medical record chat messages, emergency department (ED) visits, and unplanned clinic visits. Post-operative complications were reported using the modified Clavien-Dindo classification, and unplanned secondary procedures were also included as complications. All post-operative phone calls within the defined collection period were logged. Those calls that required intervention (such as medication prescription) were also logged as a complication. Unplanned clinic visits included unplanned telehealth appointments. Clinic visits with other non-urology providers (e.g., PCP) were not included. If the patient visited both the ED and had an unplanned clinic visit, both were separately reported.

Statistical analysis

Study data were collected and managed using redcap electronic data capture tools hosted at our institution.[12,13] redcap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies. All data analysis was performed using SPSS Statistics software (IBM SPSS Statistics for Windows, version 27.0. Armonk, NY: IBM Corp). Data are presented as means (standard deviations) or proportions (percentages). Per study objectives, analyses were performed comparing group differences (i.e., stent removed POD1 vs. Stent removed later) via chi-square tests for categorical variables or independent t-tests for continuous variables. Statistical significance was defined as $p < 0.05$ on intra-operative and post-operative clinical outcomes. A multivariable regression analysis was conducted with all demographic and perioperative variables entered as predictors of stent disposition.

RESULTS

Of the 243 included pcnls performed at our institution, 111 (46%) had stents removed on POD1 and 132 (54%) had stents removed at a later date. For those patients, the mean indwelling stent time was 6 days (range 1–48). Demographics appear in Table 1; groups were largely similar, but Black patients were less likely to have stents removed on POD1 ($p = 0.031$).

Operative data are reported in Table 2. There were several variables that demonstrated group differences in proportions of patients who had their stent removed at POD1 vs. Later, including surgeon, preoperative drainage, tract size, patient position, operative time, stone burden, stone location, and Guys Stone Score (ps < 0.03). These differences were primarily due to surgeon variability and how the procedure was performed. Despite these differences, multivariable regression modeling indicated that no surgeon, operative, nor stone variables were significantly related to longer stenting or outcomes (all ps > 0.148; Model: $p<0.001$).

Post-operative events are summarized in Table 3. There were 76 patients (31.3%) who called or messaged the office after their procedure, 31 (13%) who went to the ED (n=26, 10.7%) and/or clinic (n=6, 2.5%). When comparing patients whose stents were removed on POD1 compared to longer stented counterparts, there was no statistically significant difference in telephone calls/messages ($p = 0.081$) or ED/clinic visits ($p = 0.093$). The most common reason for a telephone call or visit to the ED was flank pain.

Forty-three (17.7%) patients reported a postoperative complication, and this did not differ by stenting group ($p = 0.647$). Most complications were either Clavien-Dindo grade I (n=19, 44.2%) or II (n=15, 34.9%). There were seven grade III complications (16.3%), which included two percutaneous angio-embolization procedures by interventional radiology for pseudo-aneurysm related post-operative bleeding, one ureteroscopy on the contra-lateral side for obstructing stones, and one stent removal in the operating room for a patient who could not tolerate removal in the office. There was one grade IV complication (ICU admission) and one post-operative mortality. The mortality did not occur at our institution, and the cause of death is unclear. The stent removal was scheduled for the day after this patient's death.

There were three (1.3%) unplanned second look procedures: two (1.8%) in the POD1 stent removal group (one had presented at an outside hospital for pain and was stented, and second look ureteroscopy showed no stones, while the other patient was found to have two obstructing 3mm fragments that were basketed out approximately two weeks post-operatively after ongoing pain); and one (0.8%, p = 0.475) in the later stent removal group (patient had ureteroscopy on POD1 after PCNL for stone fragment noted alongside the stent on post-operative imaging. That stent was removed 48 hours afterwards via tether at home. The patient then returned two days later with AKI and fever so a new stent was replaced).

DISCUSSION

Our objective was to determine whether patients who had their stent removed on POD1 presented with more post-operative events or complications as a result of earlier stent removal. POD1 stent removal after an uncomplicated PCNL can be performed safely with low rates of complications and an acceptable rate of other post-operative events compared to their counterparts that are stented for longer periods of time. Although a relatively high proportion of patients called in with questions or concerns (31.3%), few required an unplanned clinic appointment, ED visit, or an unplanned secondary procedure and thus were managed conservatively. Most commonly these calls were for pain and simple reassurance or behavioral recommendations (e.g., rest, hydration)

To our knowledge, there is no series in the current literature that directly examined the ideal length of stenting after uncomplicated PCNL. This question has been examined for patients undergoing ureteroscopy in a few published studies. Paul et al. Examined 3- vs 7-day tethered stent removal in patients who underwent unilateral ureteroscopy and found a non-significant trend towards more post-procedure events (phone calls, ED visits, extra clinic visits) in the earlier stent removal group.[14] Conversely, Komeya et al. Published a retrospective analysis comparing patients post-flexible ureteroscopy who had stent removed on POD1 versus their standard, longer-stented counterparts and found no difference in stone free rates or post-operative complications between groups.[15] More recently, Boyko et al. Performed a large retrospective cohort study looking at unplanned ED or clinic visits post-ureteroscopy in three groups based on stent duration. They also found no difference in their primary outcome between stent groups.[16] These two latter studies suggest that the indwelling ureteral stent can be safely removed at an earlier date after ureteroscopy, without an increase in post-operative adverse events, and limiting the morbidity associated with prolonged stenting.

In the PCNL literature, studies have demonstrated better pain control and shorter hospital stays in stented patients compared to those with a nephrostomy tube.[6,7,17] A few studies have examined a stent left on a tether following PCNL and shown the feasibility and safety of this approach. Berkman et al. Described antegrade placement of a stent, with the tether exiting the flank, which decreased narcotic use and hospital stay compared to standard PCNL.[9] Shpall et al. Similarly describe antegrade, tethered stent placement which was removed in the office 3-12

days after PCNL, with no noted urine leakage or subsequent complication.[10] These studies have not examined duration of stenting, and in neither study were stents removed on POD1. [9,10]
The benefits of removing a stent on POD1 (versus later) are important, and include reducing stent-associated morbidity; it obviates the inconvenient and often stressful return visits for cystoscopy to remove the stent; and the potential cost savings from these unnecessary visits. There does not appear to be significant complications with removing the stent on POD1 after an uncomplicated PCNL. In addition, there were no differences in outcomes based on the surgical approach (e.g., surgeon, tract size, patient position, etc.), and this may speak to the generalizability of safely removing a stent on POD1 regardless of the way the PCNL procedure is carried out, as long as the criteria for doing so are met.

There are also advantages of a short-term indwelling stent over a “totally tubeless” approach. For example, stenting with a Foley allows renal decompression after the procedure and allows for the rapid identification of patients with severe bleeding that may need additional procedures. Many patients live far away and express a preference to stay overnight, and this allows them to be discharged the next day without any tubes. Anecdotally, we have placed 5F ureteral catheters post-operatively for removal on POD1 that have caused renal pelvis perforation and medial urinomas on two occasions, and have since reverted to stent placement instead, with the former very seldom used for post-operative drainage. We cannot ascertain the causality of this relationship, so this may be considered a correlation until further evidence is provided.

There are several limitations to the current study. The study was retrospective in design and our baseline group demographics were similar save for race, although the exact reason why more patients identifying as Black or African American had their stents removed later is unknown from the dataset. Given our small sample size of patients identifying as Black or African American (n=17, 7.0% with n=4 or 3.6% in the POD1 group and n=13 or n=9.8% in the ‘later’ group), post-hoc comparisons were not possible. However, recent literature has suggested that Black race is a correlate of kidney stone disease prevalence and comorbidities.[18] A recent 50-year systematic review of several large epidemiologic studies[19] suggesting disproportionate increases in incidence and prevalence of kidney stone disease among Black individuals, with health disparities further exacerbating these issues. Some work has also indicated that Black patients wait disproportionately long for surgery compared to other races and ethnicities, and that this may further interact with insurance status.[20]

Another limitation due to the retrospective and descriptive / exploratory nature of this study is that prospective randomization could not occur. This represent an important future direction. On this point, additional post-hoc analyses of effect size were also not included in our group comparisons. Stone-free rates were not measured in our series given that long-term metrics were not tracked via this retrospective review. However, on a practical basis, only two patients required a secondary unplanned procedure as a result of the stent being removed on POD1, only one of which was found to have residual stones.

Finally, we also consider that confounding variables may have impacted results, given that individual surgeons could affect both operative "exposure" variables as well as post-operative complications or calls (i.e. "outcome" variables). Finally, given the suggestion from one of our reviewers that we test for multicollinearity to indicate any correlation between surgeon and certain operative variables, collinearity diagnostics were run. Values were acceptably low (VIF between 1-5) in Model 1 (Table 1), with similarly low values in Model 2 (Table 2), save for surgeon (VIF = 6.00) and patient positioning (VIF = 5.40), which is a reflection of differences in clinical practice between the two surgeons who performed all pcnls at our institution. Collinearity diagnostics were within an acceptably low range for all other variables in our model, suggesting no additional consideration was needed.

Future directions could assess patient quality of life following PCNL, with the purpose of better determining patient experience across groups and better accounting for the patient experiences and preferences. We hypothesize that patients who have the stent removed on POD1 after PCNL are more satisfied than their longer stented counterparts because of the elimination of both stent colic and office visit for stent removal. Additionally, more extensive pre- and post-operative patient counseling, with a focus on post-operative pain, remains an important need given the relatively high amount of telephone calls and unplanned visits related to pain control that were ultimately conservatively managed in most patients.

CONCLUSIONS

In a limited retrospective review, stent removal POD1 after uncomplicated PCNL did not lead to an increase in short-term post-operative phone calls, complications, or ED/clinic visits compared to their longer stented counterparts.

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FIGURES AND TABLES

Figure 1. Flow chart indicating the flow of records analyzed, including exclusion criteria, and distribution of patients into final categories for data analysis. PCNL: percutaneous nephrolithotomy; POD: postoperative day.

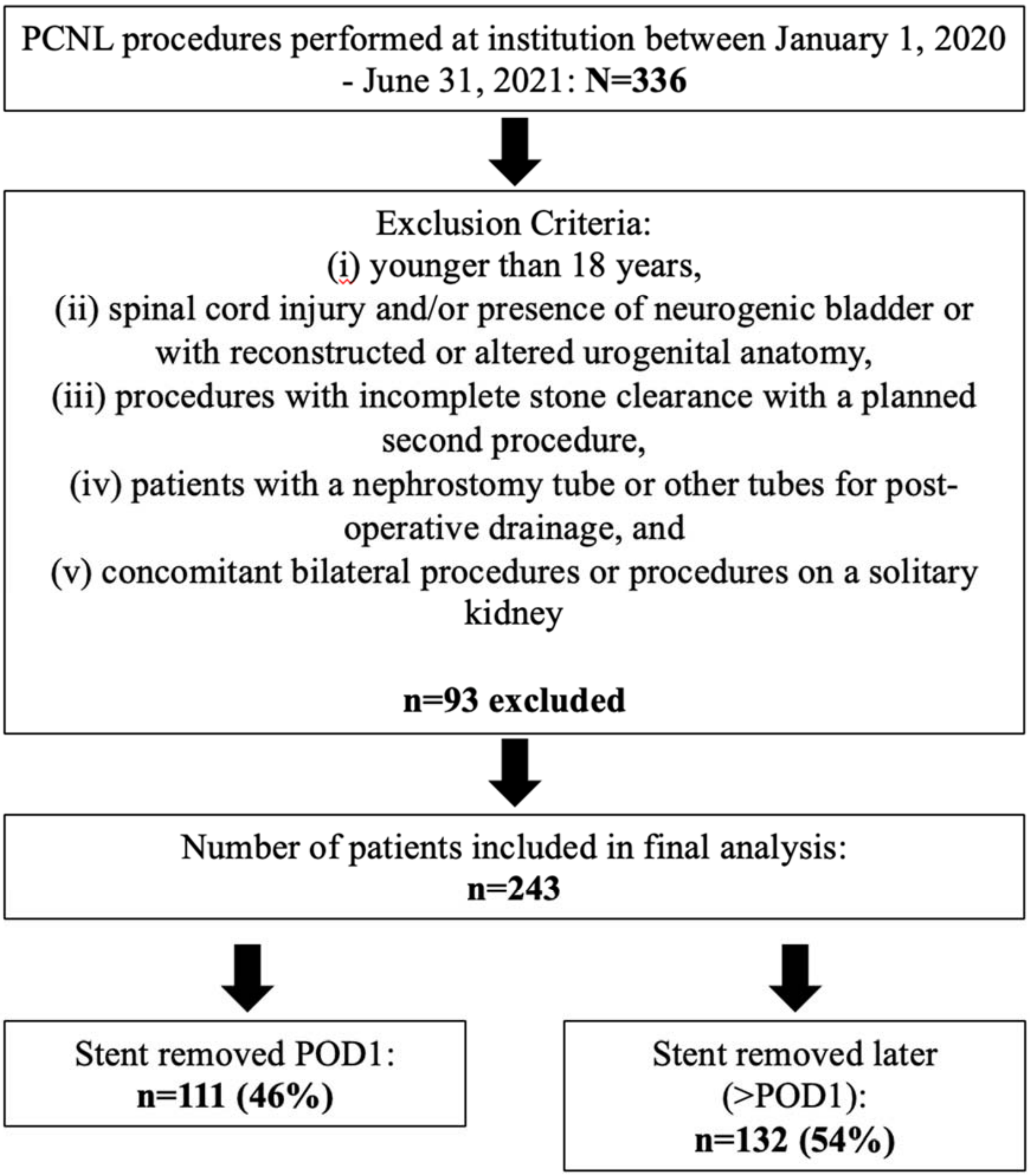

Table 1. Demographics data of analyzed groups

Variable	POD1 (%) n=111	Later (%) n=132	Total (%) n=243	Group comparison p	Multivariable regression p
Age (years), mean (SD)	54.4 (15.2)	55.9 (15.6)	55.2 (15.4)	0.444	0.091
Sex Male Female	 53 (45.3%) 58 (52.3%	 64 (48.5%) 68 (51.5%)	 117 (48.1%) 126 (51.9%)	0.909	0.597
Race White Black or African American Asian Other Unknown	 105 (94.6%) 4 (3.6%) 0 (0%) 2 (1.8%) 0 (0%)	 107 (81.1%) 13 (9.8%) 3 (2.3%) 8 (6.1%) 1 (0.8%)	 212 (7.0%) 17 (45.3%) 3 (1.2%) 53 (45.3%) 1 (0.4%)	0.031	0.152
Ethnicity Not Hispanic/ Latino Hispanic/Latino	 108 (97.3%) 3 (2.7%)	 126 (95.5%) 6 (4.5%)	 234 (96.8%) 9 (3.7%)	0.449	0.846
BMI Underweight (<18.5) Healthy weight (18.5–24.9) Overweight (25–29.9) Obese (30–40) Morbidly obese (>40)	 3 (2.8%) 17 (15.6%) 28 (25.7%) 46 (42.2%) 15 (13.8%)	 2 (1.6%) 24 (19.0%) 32 (25.4%) 51 (40.5%) 17 (13.5%)	 5 (2.1%) 41 (17.4%) 60 (25.5%) 97 (41.3%) 32 (13.6%)	0.936	0.240
Smoking history None Former Current	 68 (61.3%) 24 (21.6%) 19 (17.1%)	 71 (54.2%) 36 (27.3%) 23 (17.7%)	 139 (57.4%) 60 (60.0%) 42 (17.4%)	>0.268	>0.714
History of stones No Yes	 26 (23.4%) 85 (76.6%)	 31 (23.7%) 100 (76.3%)	 57 (23.6%) 185 (76.4%)	0.965	0.434
ASA score 1 2 3 4	 5 (4.5%) 52 (46.8%) 52 (46.8%) 2 (1.8%)	 5 (3.8%) 61 (46.6%) 62 (47.3%) 3 (2.3%)	 10 (4.1%) 113 (46.7%) 114 (47.1%) 5 (2.1%)	0.986	0.399
Stone burden				0.011	0.436

<2 cm	49 (44.5%)	42 (31.8%)	91 (37.6%)		
2–5 cm	59 (53.6%)	77 (58.3%)	136 (56.2%)		
>5 cm	2 (1.8%)	13 (9.8%)	15 (6.2%)		
Stone location				<0.001	0.546
Ureter	1 (0.9%)	13 (9.8%)	14 (5.8%)		
Renal	97 (87.4%)	85 (64.4%)	182 (74.9%)		
Both	13 (11.7%)	34 (25.8%)	47 (19.3%)		
Stone analysis				0.06	0.589
Caox	75 (69.4%)	76 (59.4%)	151 (64.0%)		
Caphos	3 (2.8%)	11 (8.6%)	14 (5.9%)		
CA	9 (8.3%)	18 (14.1%)	27 (11.4%)		
Uric acid	13 (12.0%)	14 (10.9%)	27 (11.4%)		
Cystine	2 (1.9%)	0 (0%)	2 (0.8%)		
Struvite	6 (5.6%)	5 (3.9%)	11 (4.7%)		
Other	0 (0%)	4 (3.1%)	4 (1.7%)		
Mixed stone? 'Yes'	61 (57.5%)	59 (46.8%)	120 (51.7%)	0.104	0.148
Guys stone score				0.003	0.989
1	48 (43.2%)	32 (24.6%)	80 (33.2%)		
2	49 (44.1%)	73 (56.2%)	122 (50.6%)		
3	13 (11.7%)	15 (11.5%)	28 (11.6%)		
4	1 (0.9%)	10 (7.7%)	11 (4.6%)		

P-values for group comparisons were calculated based on chi-square analyses for categorical variables and independent samples t-tests for continuous variables. P-values for multivariable regression analyses were run with age, sex, race, ethnicity, BMI, smoking history, history of stones, ASA score, stone burden, stone location, stone analysis, mixed stone, and Guy's Stone Score were entered as predictors for this model. ASA: American Society of Anesthesiologists; BMI: body mass index; SD: standard deviation.

Table 2. Operative and stone data between the two groups					
	POD1 (%) n=111	**Later (%) n=132**	**Total (%) n=243**	**Group comparison p**	**Multivariable regression p**
Surgeon				<0.001	0.191
BK	83 (74.8%)	65 (50.0%)	148 (61.4%)		
MS	28 (25.2%)	65 (50.0%)	93 (38.6%)		
PCNL Laterality				0.560	0.839
Right	43 (38.7%)	56 (42.4%)	99 (40.7%)		
Left	68 (61.3%)	76 (57.6%)	144 (59.3%)		
Preoperative Drainage				0.023	>0.475
Stent	20 (18.0%)	19 (14.4%)	39 (16.0%)		
Neph tube	4 (3.6%)	15 (11.5%)	19 (7.9%)		
Tract size				<0.001	0.602
Standard (>22 F)	33 (29.7%)	72 (54.5%)	105 (43.2%)		
Mini (<22 F)	78 (70.3%)	60 (45.5%)	138 (56.8%)		
Patient position				<0.001	0.912
Supine	84 (75.7%)	70 (53.0%)	154 (63.4%)		
Prone	27 (24.3%)	62 (47.0%)	89 (36.6%)		
Lithotripter				0.165	0.754
Laser	69 (65.7%)	68 (53.5%)	137 (59.1%)		
Shockpulse/ Trilogy	29 (27.6%)	46 (36.2%)	75 (32.3%)		
Both	7 (6.7%)	13 (10.2%)	20 (8.6%)		
Concomitant procedure	37 (33.3%)	56 (42.4%)	93 (38.3%)	0.146	0.548
Operative time (minutes)	Mean=90.5 (SD=23.0)	Mean=100.6 (SD=30.2)	Mean=96.0 (SD=27.5)	0.004	0.559

P-values for group comparisons were calculated based on chi-square analyses for categorical variables and independent samples t-tests for continuous variables. P-values for multivariable regression analyses were run with surgeon, laterality, preoperative drainage, tract size, patient position, lithotripter, concomitant procedure, operative time were entered as predictors for this model. PCNL: percutaneous nephrolithotomy; POD: postoperative day.

Table 3. Summary of postoperative events and complications between early vs. later stent removal				
	POD1 n=111 (% group, % total)	**Later (%) n=132 (% group, % total)**	**Total n=243 (%)**	**p**
Postoperative complications	21 (18.9%, 8.6%)	22 (16.7%, 9.1%)	43 (17.7%)	0.647
Grade I	11 (52.4%, 4.5%)	8 (36.4%, 3.3%)	19 (44.2%)	0.433
Grade II	8 (38.1%, 3.3%)	7 (31.8%, 2.9%)	15 (34.9%)	
Grade III	2 (9.5%, 0.8%)	5 (22.7%, 2.1%)	7 (16.3%)	
Grade IV	0 (0%, 0%)	1 (4.5%, 0.4%)	1 (2.3%)	
Grade V	0 (0%, 0%)	1 (4.5%, 0.4%)	1 (2.3%)	
Phone calls	41 (36.9%, 16.9%)	35 (26.5%, 14.4%)	76 (31.3%)	0.081
ED/clinic visits				
ED	15 (13.5%, 6.2%)	11 (42.3%, 4.5%)	26 (10.7%)	0.193
Clinic	4 (3.6%, 1.6%)	2 (1.5%, 0.8%)	6 (2.5%)	0.296
Chief complaint				
Fevers/chills	2 (1.8%, 0.8%)	1 (0.8%, 0.4%)	3 (1.2%)	0.463
Nausea/ Vomiting	4 (3.6%, 1.6%)	0 (0%, 0%)	4 (1.6%)	0.028
Flank pain	13 (11.7%, 5.3%)	7 (5.3%, 2.9%)	20 (8.2%)	0.070
Bladder pain	1 (0.9%, 0.04%)	1 (0.8%, 0.4%)	2 (0.8%)	0.902
Other	4 (3.6%, 1.6%)	4 (3.0%, 1.6%)	8 (3.3%)	0.803
Unplanned secondary procedure	2 (1.8%, 0.8%)	1 (0.8%, 0.4%)	3 (1.3%)	0.475

P-values for group comparisons were calculated based on chi-square analyses for categorical variables and independent samples t-tests for continuous variables. ED: emergency department.