Salvage Percutaneous Nephrolithotomy: Analysis of Outcomes Following Initial Treatment Failure

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Abstract

Introduction: Percutaneous nephrolithotomy (PCNL) has potential for morbidity or failure. There are limited data regarding risk factors for failure and no published reports of surgical outcomes among patients with prior failed attempts at percutaneous stone removal.

Methods: Patients referred to three medical centers after prior failed attempts at PCNL were identified. Retrospective chart review was performed analyzing reasons for initial failure and outcomes of salvage PCNL. Outcomes were compared to a prospectively maintained database of over 1200 patients undergoing primary procedures.

Results: Thirty-one patients underwent salvage PCNL. Unsuitable access to the stone was the leading reason for failure (80%). Other reasons included infection, bleeding, and inadequate instrument availability (6.5% each). Compared to patients undergoing primary PCNL, those undergoing salvage were more likely to have staghorn calculi (61.3% vs. 31.4%, $p<0.01$), larger maximum stone diameter (3.7 cm vs. 2.5 cm, $P<0.01$), and require secondary procedures (65.5% vs. 42.1%, $p<0.01$). There was no significant difference between cohorts for the remainder of demographics or perioperative outcomes. All patients were deemed completely stone free except one who elected to observe a 3 mm non-obstructing fragment.

Conclusions: Despite the more challenging nature and prior unsuccessful attempts at treatment, outcomes of salvage PCNL were nearly similar to primary PCNL.

Introduction

Percutaneous nephrolithotomy (PCNL) is supported by the American Urological Association (AUA) and European Association of Urology (EAU) as first line treatment for large and complex upper urinary tract stones.[1, 2] This procedure can be challenging and carries a risk of significant morbidity. It has been estimated that complications after PCNL can be as high as 25%, nearly 5% of which are Clavien grade 3 or higher.[3] Despite such challenges, PCNL remains a commonly performed procedure accounting for approximately 5% of all stone-related surgeries.[4, 5]

An important step in PCNL is obtaining proper access. Inability to appropriately perform this critical maneuver can lead to morbidity and sometimes treatment failure. Prior studies estimate that it takes a minimum of 60 cases to achieve competence in obtaining access and 115 procedures prior to achieving excellence.[6, 7] Subsequently, the number of urologists who obtain their own access is low, estimated at 11% in 2003, with a majority favoring to have access obtained by radiologists.[8] While this collaboration is most often successful, it can pose unique challenges, particularly in the event that initial access is found to be unsuitable and the radiologist is not present to perform additional access to allow for safe and effective stone removal. In such cases, the safest option may be to abort the procedure. Given the inherent complexity of PCNL, the frequency of its utilization and the logistic challenges in coordinating access, treatment failures would be expected from time to time. Surprisingly though, studies focusing on PCNL treatment failures are universally absent from the published medical literature.

Conversely, treatment failures after other minimally invasive alternatives treatments, such as shock wave lithotripsy (ESWL) and ureteroscopy (URS) are well characterized.[9-13]

One potential reason for this discrepancy in publication is the fact that these alternative procedures have secondary treatment options such as PCNL to use for more definitive outcomes. Failed PCNL, however, represents a much greater clinical challenge given the more invasive nature of the procedure and the lack of suitable secondary treatment options. Less invasive salvage procedures post PCNL failure including ESWL and URS would be expected to have suboptimal stone free rates, and more invasive approaches such as open and laparoscopic or robotic assisted renal surgery carry even greater potential for morbidity. In such situations, a repeat attempt at PCNL is potentially the best choice. However, to date there are no data regarding outcomes of PCNL performed in the salvage setting. Such information is necessary not only to help guide clinical care but also to the patient who may have experienced a failed initial attempt at PCNL and may otherwise be skeptical of repeating a complex and invasive procedure that has already proven to be unsuccessful on one occasion. We seek to assess treatment outcomes of PCNL performed in the salvage setting, as well as better characterize risk factors for primary PCNL failure.

Methods

PCNL cases accrued from IRB-approved PCNL databases from three high volume endourologists experienced in PCNL were reviewed to identify patients referred to them for attempts at salvage PCNL. "Salvage" was defined as a patient referred from another provider after an initial unsuccessful attempt was made to treat an upper tract stone using a percutaneous approach. Retrospective chart review was performed analyzing both the transferred records brought with the patient at the time of initial consultation, as well as the hospital chart pertaining to the patient's ultimate salvage procedure. Patient demographic, perioperative, and operative data were collected both from the initial attempt at treatment, as well as the salvage procedure.

Salvage PCNL technique was performed at the discretion of the treating surgeon. In all cases, new access was obtained by the referral endourologist using standard biplanar fluoroscopy and either a bulls-eye or triangulation technique. The decision to perform multiple accesses was at the discretion of the surgeon in order to facilitate efficient and complete stone removal. All patients underwent cross sectional imaging on post-operative day one to identify residual fragments and/or other post-procedural complications. Patients were offered secondary procedures for definitive stone removal in the event that any residual fragments were seen on imaging. Patients were ultimately deemed stone free either by the absence of residual fragments on post-operative CT or via direct second look inspection of the kidney.

Patient demographics and operative variables from the salvage cohort were then compared to the same variables from a prospectively maintained database of over 1200 patients undergoing primary percutaneous nephrolithotomy. Statistical analysis was performed using IBM:SPSS Statistics Version 22 (Armonk, NY). Continuous measures were compared between groups using Student t-tests and categorical measures were compared between groups using Fisher's exact tests with $p<0.05$ being considered statistically significant.

Results

Thirty-one patients underwent salvage PCNL. Reasons for initial treatment failure are listed in Table 1. Unsuitable access to the stone was the most common reason for prior failed attempt with 80% of the salvage procedures having had prior difficulty accessing and treating the stone. Other reasons for failed PCNL included infection (hemodynamic instability in the presence of purulent urine), excess bleeding, and inadequate instrument availability (6.5% each). Percutaneous access during the initial PCNL failure was obtained exclusively by interventional radiologists in 73.3% of cases, urologists in 20%, and by members of both specialties in 6.5%.

When comparing the salvage cohort to a group of over 1200 patients undergoing primary PCNL (Table 2), there were no demonstrable differences in terms of baseline patient demographics. Notably, patients in the salvage cohort did not demonstrate greater BMI, older age, or anatomic renal abnormalities. Stone characteristics, however, did differ between cohorts with the salvage cohort more likely to have staghorn calculi (61.3% vs. 31.4%, $p<0.001$) and larger maximum stone diameter (3.7 cm vs. 2.5 cm, $P<0.001$).

Operative outcomes were overall favorable in the salvage setting (Table 3) with no instances of inability accessing the stone for treatment. While stone free rate was ultimately quite high (97%), a majority of patients (65.5%) required secondary procedures to facilitate or ensure complete stone removal. This was significantly higher compared to the primary PCNL cohort whereby secondary procedures were only necessary in 42% of cases ($p<0.01$). Notably, there was otherwise no difference in terms of requiring multiple access, complications, transfusions, change in hemoglobin or serum creatinine, operative time, and length of stay.

Discussion

PCNL is a technically challenging surgical procedure with a relatively high potential for morbidity.[14] In fact, the inherent complexity of the procedure has led to spontaneous regionalization of this procedure towards hospitals with high volume, large bed size, and academic affiliations.[15] Despite the known potential for complications and treatment failure, little has been published regarding the ultimate fate of procedures that do not go according to plan. In particular, no studies have addressed outcomes of such cases when referred for a subsequent "salvage" percutaneous procedure.

We found that compared to a large cohort of over 1200 patients undergoing primary PCNL, risk of PCNL failure appeared to be more closely related to the complexity of the stone rather than any identifiable patient factors as evidenced by increased stone size and staghorn stone configuration in the salvage cohort. This finding is not necessarily surprising as prior studies have demonstrated lower success rates with increasing stone burden and complexity.[16] Notably, despite the increased complexity of the stones and the fact that all had been subjected to prior incomplete treatments, there were minimal differences in surgical outcomes to patients undergoing primary procedures. The one difference in outcomes was an increased need for secondary procedures in the salvage PCNL cohort, presumably a reflection of increased stone complexity. Turna and associates similarly found the need for secondary procedures after PCNL was directly linked with stone surface area. Those with stones 500 mm^2 or less required secondary procedures 15% of the time compared to 25% for stones 1000-1500 mm^2 and 50% for stones greater than 2500 mm^2.[16] We believe that the high rates of secondary procedures seen in both our primary and salvage cohorts reflects our general practice of routine post-operative CT scans to identify residual fragments, as well as aggressive efforts to achieve true stone free status with zero residual stones and no "clinically insignificant fragments".

Prior studies analyzing outcomes of PCNL performed in the salvage setting are limited to PCNL post-ESWL failure only and no study to our knowledge has assessed outcomes of salvage PCNL post-initial PCNL failure. Zhong and colleagues found that patients undergoing PCNL after prior treatment failure with ESWL had worse surgical outcomes compared to PCNL patients who were treatment naïve.[10] The prior ESWL failure cohort experienced longer operative times (95.8 min vs. 80.6 min, $p<0.05$) and lower stone free rates (83.9% vs. 93.4%). The authors proposed scattering of stones after ESWL, as well as embedded stones within the urothelial mucosa, as explanations for their findings. Similar findings were demonstrated by Yuruk et al who also analyzed a large cohort of over 200 patients undergoing PCNL post recent ESWL and compared outcomes to patients who were ESWL naïve.[11] Interval time between ESWL and PCNL was 3.4 months. Mean operative time and fluoroscopic screening time adjusted for stone size was longer in the cohort having had prior ESWL (8.6 min/cm vs. 7.3 min/cm, 1.65 min/cm vs. 1.16 min/cm). Stone free rates were comparable between groups. Conversely, Resorlu et al found no difference in surgical outcomes between patients with prior ESWL failure undergoing PCNL compared to ESWL naïve patients with no difference in operative times, complications, hospital stay, or stone free rate (89% vs. 88.5%).[9]

Such findings from PCNL after failed ESWL are not necessarily applicable to those post failed PCNL. First, PCNL is a more definitive procedure in terms of stone clearance. Thus, prior treatment failures with this approach would likely be less common and potentially indicative of underlying complexities inherent to the patient, renal anatomy, stone configuration, or experience of the urologist/radiologist. As expected, we found that stones treated with prior unsuccessful attempts at PCNL were, in fact, more complex than those without prior PCNL failures. However, to our surprise, we did not find any increased likelihood of patient or anatomic variables compared to those who were undergoing primary PCNL. To date, the only comparable studies examining this concept apply to PCNL with remote histories of either prior PCNL or open stone surgery. Outcomes among these cases have been comparable to those without a prior history of percutaneous or open surgery. However, the time interval between procedures has been several years[14, 17, 18]. The unique difference in our study is the fact that the salvage PCNL was being done shortly after a recent invasive procedure for the same stone as opposed to a different stone previously treated many years ago. In fact, the median time from PCNL failure to PCNL salvage was only 48 days. The fact that outcomes were comparable in regards to both treatment efficacy and safety suggests that a prior failure is not a contraindication towards a repeat attempt at PCNL in experienced hands.

Our study has several strengths. First is the relatively large number of patients undergoing the salvage procedure considering that to date there is no published evidence regarding such procedures. Additionally, comparison to a very large cohort of patients undergoing primary PCNL allows for a more comprehensive analysis demonstrating that salvage PCNL is not only possible but appears to be equally efficacious and safe as a primary PCNL at expert centers. The study has several limitations as well. For one, details and reasons for primary PCNL failure were limited to what was included in the transfer records and, while best efforts were made to identify the precise etiology of failure, more detailed information such as baseline PCNL experience of the surgeon and radiologist and precise explanations for unsuitable access were not possible in every case. Thus, it is possible that there are unrecognized confounders potentially associated with primary failure besides large stone size and staghorn status. Furthermore, while the number of salvage procedures is considerable relative to the available literature on the subject, it remains a limited number potentially restricting the generalizability of the outcomes. However, one would hope from a patient safety perspective that the number of patients experiencing PCNL failures is small in general and presumably the reason such patients are not encountered more frequently. Finally, all salvage procedures were performed by highly experienced endourologists, potentially an explanation for the high success rates. However, given the baseline complexity of the stones, the prior history of unsuccessful treatment and the implications of an additional failed procedure, we advocate that such patients should be referred to providers with the most experience with PCNL.

Conclusions

Salvage PCNL performed shortly after an initial PCNL treatment failure appears to be equally safe and efficacious as primary PCNL. Risk factors for failure appear to be mainly driven by the complexity of the stone as evidenced by larger size and staghorn status in the PCNL failure cohort, whereas there were no differences in patient demographics between the two cohorts. These findings might be utilized to improve pre-operative counseling regarding the possibility of treatment failure prior to the procedure and post-operative counseling in the event that primary PCNL is unsuccessful.

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Table 1: Reasons for primary PCNL failure

	Percentage
Unsuitable access	25/31 (80.6%)
Bleeding	2/31 (6.5%)
Infection	2/31 (6.5%)
Inadequate instruments	2/31 (6.5%)

Table 2: Preoperative patient demographics and stone factors in salvage PCNL vs. primary PCNL cohorts. Statistically significant variables in bold.

Variable	Salvage PNL		Primary PNL		P-value
	n		n		
Gender	31		1253		0.147
Male		11 (35.5%)		619 (49.4%)	
Female		20 (64.5%)		634 (50.6%)	
Age (years)	31	51.3 (13.2)	1253	53.5 (15.6)	0.421
BMI (kg/m^2)	31	32.5 (7.3)	1150	31.4 (9.2)	0.497
Anatomic renal abnormality	31	2 (6.5%)	1253	188 (15.0%)	0.301
Staghorn stone	**31**	**19 (61.3%)**	**1247**	**391 (31.4%)**	**<0.001**
Maximum stone diameter (cm)	**25**	**3.7 (2.1)**	**532**	**2.5 (1.6)**	**<0.001**

Table 3: Comparison of peri-operative and post-operative variables between salvage PCNL and primary PCNL cohorts. Statistically significant variables in bold.

Multiple access	31	15 (48.4%)	1253	412 (32.9%)	0.082
Mean # access/case	31	1.6 (0.8)	1228	1.4 (0.8)	0.229
Surgery time (min)	28	142.8 (48.9)	896	127.9 (53.8)	0.146
Length of stay (days)	31	3.1 (3.2)	1250	2.5 (2.2)	0.140
Need for secondary procedure	**31**	**65.5%**	**1253**	**42.1%**	**0.004**
Transfusion	31	3 (9.7%)	1250	44 (3.5%)	0.102
Complication	31	6 (19.4%)	1253	160 (12.8%)	0.277
Change in 24 hr Cr (mg/dL)	30	-0.18 (0.22)	1172	-0.19 (0.33)	0.808
Change in 24 hr HGB (g/dL)	29	-2.0 (1.4)	1188	-2.1 (1.4)	0.748
Positive stone culture	31	7 (22.6%)	1250	303 (24.2%)	1.0

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