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Fate of Residual Stones After Percutaneous Nephrolithotomy: A Critical Analysis

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Abstract

Purpose: To analyze the fate of residual stones after percutaneous nephrolithotomy (PCNL) and identify the factors that predict spontaneous passage.

Patients and Methods: We retrospectively analyzed the records of 2469 patients who underwent PCNL at our center between January 2000 to January 2008.

Results: Residual fragments (RF) were identified in 187 (7.57%) patients. The most common site of RF was lower calix (57.7%), and the mean size of RF was $38.6 \pm 52\,mm^2$. Eighty-four stones passed spontaneously at a mean follow-up of 24 months (range 1–100 mos). Of the stones that passed spontaneously, 65.47% did so in 3 months. RF $<25\,mm^2$ and those situated in the renal pelvis had the best chance of clearance. Stepwise multiple regression analysis showed that a history of intervention ($P < 0.006$), metabolic abnormalities such as hypercalcuria ($P < 0.001$) and hyperuraecemia ($P < 0.03$), preoperative nephrostomy drainage ($P < 0.05$), presence of a Double-J stent, ($P < 0.001$), time of presentation of residue ($P < 0.08$), size of residue ($P < 0.007$), and surgeon experience ($P < 0.001$) were significant factors in predicting the fate of RF after PCNL.

Conclusions: The most common site of post-PCNL RF was the lower calix. Renal pelvic RF $<25\,mm^2$ have the best chance of spontaneous passage. Approximately half the RF will pass spontaneously, and the majority will clear in 3 months. The size of the residual stone, history of intervention, renal failure, and metabolic hyperactivity are predictors of persistence of RF.

Introduction

Since first performed by Fernstorm and Johansson in 1976 percutaneous nephrolithotomy (PCNL) has emerged as a management option of choice for large volume renal calculi.[1] The rapid emergence of shockwave lithotripsy (SWL) in the 1980s had brought in the concept of clinically insignificant residual fragments (CIRF). Despite the common use of the terminology, there is no concensus on the maximum size of the stone fragment that is not significant.

Although data are available regarding the outcome of long-term follow-up of CIRF after SWL,[2] no data are available regarding the post-PCNL fate of residual fragments (RF) and factors that predict spontaneous passage . We present our experience regarding the natural history of RF after PCNL and factors that predict their spontaneous passage.

Patients and Methods

We retrospectively analyzed the records of 2469 patients who underwent PCNL at our center from January 2000 to January 2008. Detailed data were available in 187 (7.57%) patients with RF. The parameters analyzed are summarized in Tables 1 and 2.

During PCNL, we determine the site of optimal renal access after studying the stone configuration and intrarenal anatomy of the collecting system. In complex and staghorn stones, one of the punctures/tracts will be the main one that would clear maximum stone burden; the remaining clear the peripheral caliceal stones. We prefer multiple peripheral tracts to clear all caliceal stones that may not be cleared easily through the main tract. Tract dilatation is performed with a screw dilator, which allows single-step dilatation to 14 F; thereafter, the tract is dilated with serial telescopic Alken dilators.

We limit our nephroscopy time to one and one-half hours. The procedure is abandoned if there is significant bleeding that obscures vision. If we have not used the puncture in the first sitting and feel a need to dilate the tract in a subsequent sitting for residual stones, a 14F Malecot catheter is placed for tract maturation. A 20 or 22F Nelaton catheter is placed as a nephrostomy tube; the secondary tracts are drained by 12F or 14F tubes. Apart from second-look procedures and multiple tracts, flexible nephroscopy was also used to avoid residual stones.

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Table 1. Factors Analyzed

Patient-related factors	*Surgeon-related factors*
Anatomic anomalies (ectopic kidney, ureteropelvic junction obstruction, horseshoe kidney)	Operating room time
Family history of stone disease	Number of punctures
History of intervention for stones	Site of puncture
Stone location	Number of tracts used
Stone bulk	Number of stages
Serum uric acid	Energy used for fragmentation
Serum calcium	Complications
Serum creatinine	Need for Double-J stenting
	Preoperative culture
	Previous nephrostomy drainage
	Surgeon experience

RFs were left behind if they were not seen on fluoroscopy intraoperatively, they were thought to be in an inaccessible calix, the general condition of the patient did not allow further interventions or extra tracts, or the operating surgeon deemed the stone insignificant.

The stone bulk was measured by graph paper tracings of two-dimensional projection of an anteroposterior plain radiograph. Stones were categorized as pelvic (no caliceal involvement), caliceal, multiple, staghorn, or partial staghorn. Partial staghorn was defined as renal pelvic calculi with extension into at least two infundibula or calices. Complete staghorn was defined as renal pelvic calculi extending into all calices and filling at least 80% of the collecting system. Surgeon experience was classified as grade A if the surgeon had more than 10 years of experience in endourology and Grade B if he or she had fewer than 10 years of experience.

The size of the residual stone was assessed with the combination of ultrasonography and plain radiography of the kidneys, ureters, and bladder. The radiologic assessment was performed at 48 hours and at 1-month and 3-month follow-up. The residual stones were defined as those stones that were diagnosed within 3 months of follow-up. For the past year, we have performed noncontrast CT at follow-up evaluation.

In our analysis, outcome and event possibilities were compared in residual stones $<25\,mm^2$, $50\,mm^2$ and $>100\,mm^2$. SPSS 15.0 package was used for multivariate stepwise regression analyses, 2×2 contingency tables were used to assess the chance of clearance of stones, keeping stone size and site as a dependent variable. The P value of <0.05 was considered significant.

Table 2. Parameters Analyzed for Residual Stones

Time of presentation
Presenting symptom (incidental pain, hematuria, lithuria, uremic symptoms, infection
Site of residue
Size of residue
Clearance

Results

The demographic data are depicted in Table 3. The most common site of RF was lower calix (108/187) 57.7% (Fig. 1). The mean size of RF was $38.6 \pm 52\,mm^2$. Eighty-four patients passed RFs spontaneously at a mean follow-up of 24 months (range1–100 mos). RF (65.47%) that passed spontaneously did so in 3 months (Fig. 2). As the size of RF increased, the chance of spontaneous passage decreased. None of the RFs $>100\,mm^2$ passed spontaneously (Fig. 3). RFs $<25\,mm^2$ and situated in the renal pelvis had the best chance of clearance (Table 4).

Stepwise multiple regression analysis showed that a history of intervention ($P < 0.006$), metabolic abnormalities such as hypercalcuria ($P < 0.03$) and hyperuraecemia ($P < 0.001$), preoperative nephrostomy drainage ($P < 0.05$), presence of a Double-J stent ($P < 0.001$), time of presentation of residue ($P < 0.08$), size of residue ($P < 0.007$), and surgeon experience ($P < 0.001$) were significant factors in predicting the fate of RF after PCNL (Table 5). In our study, RFs in patients with renal insufficiency lead to rapid deterioration of renal function (Fig. 4).

Discussion

Historically, the goal of surgical intervention for stone disease was complete stone clearance. With the advent of newer minimally invasive therapies such as SWL and PCNL, the term residual stone/CIRF has come into vogue.[3] CIRFs are usually post-SWL RFs that are <4 mm, asymptomatic, non-

Table 3. Demographic Data with Stone Characteristics

Parameters	*Number of patients*
Age (yrs)	42.5 ± 14.5
Bilateral stones	32
Original Stone bulk (mm^2)	697 ± 734
No. of RF with renal insufficiency	22
Anatomic anomalies	
Ectopic kidney	1
UPJ obstruction	4
Family history of stone disease	17
History of intervention	
Previous SWL	20
Previous open surgery for stone	61
Location of stones	
Lower calyx	35
Pelvis	53
Upper ureter	14
Upper calix	06
Middle calix	05
Multiple complex calculi	34
UPJ calculus	6
Staghorn calculus	34

RF = residual fragments; SWL = shockwave lithotripsy; UPJ = ureteropelvic junction.

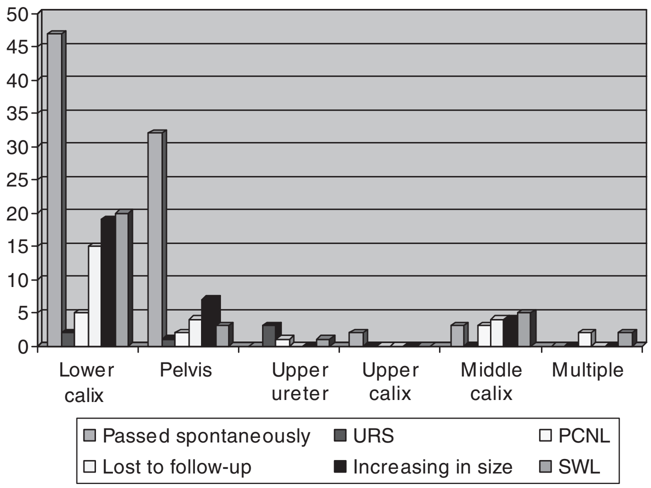

FIG. 1. Fate of RF, depending on site of the RF. URS = ureteroscopy; SWL = shockwave lithotripsy; PCNL = percutaneous nephrolithotomy.

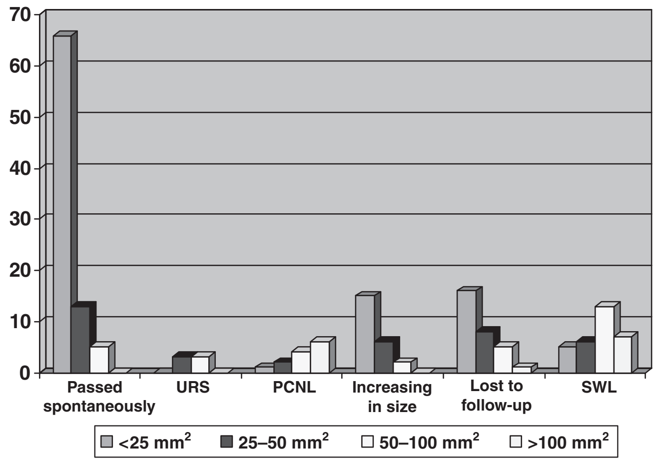

FIG. 3. Fate of RF, depending on size of RF. URS = ureteroscopy; PCNL = percutaneous nephrolithotomy; SWL = shockwave lithotripsy.

infectious, and associated with sterile urine. By extension, this defines stones of similar character left behind after PCNL.[4]

PCNL should aim to achieve maximum stone clearance. Theoretically, the reason for RFs are migration of stone or stone fragments in a inaccessible calix, termination of the procedure because of bleeding, complex anatomy increasing the technical difficulty, and inability to visualize the stone on fluoroscopy.

The significance of RF centers around two problems: One of stone recurrence/remnant stone growth and recurrent urinary tract infection.[5] Although various reports are available regarding outcomes of RF after SWL, the literature is scant regarding outcomes of RF after PCNL.

In our series, 65.5% of RF passed spontaneously within 3 months of the procedure. Our findings are in accordance with the stone-free rate of CIRF after SWL. Osman and associates[6] noted that 78.6% of stones cleared within a few weeks without any recurrence at 5 years. Our data suggest that size of the RF is an important factor in predicting the outcome. None of the RF $>100\,mm^2$ passed spontaneously. Similarly, our analysis suggests that as the size of RF increases, the need for intervention increases exponentially.

If we consider the influence of stone location on spontaneous clearance in our study, statistically the best clearance was seen with pelvic residue. We think that the dependent anatomy of the lower calix acts as a hindrance to spontaneous passage of RF. Reports on fragment clearance after SWL of distinct anatomic location are inhomogenous and contradictory. Although some groups reported better clearance of RFs in upper calix than in the lower calix, this was presumed to be caused by the gravity effect.[6–9]

On multivariate analysis in our study, any previous interventions in the form of SWL, PCNL,or open surgery have significantly lower clearance rates of RF. Various studies have confirmed that PCNL in patients with a history of open surgery takes a longer time and has a higher chance of the need for auxillary procedures. A peculiar problem in these patients is that stone removal from a scarred collecting system might be difficult, because some stones are likely to be embedded in the parenchyma. The reason for poor clearance of RF in these patients might be the distorted pelvicaliceal anatomy.[10]

Long-term renal function preservation in patients with complex stone disease depends on adequate blood pressure control, stone size, and stone clearance status. Calcium oxalate crystals are known to stimulate proliferation of renal interstial cells, thus triggering scarring.[11] Our study suggests

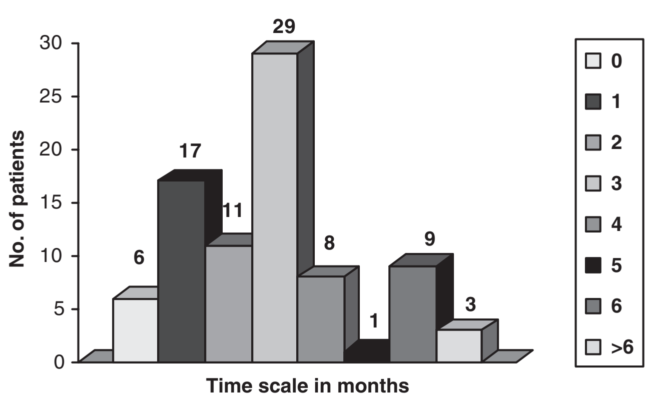

FIG. 2. Graph depicts spontaneous passage of RF; majority cleared in 3 months.

Table 4. Parameters that Predict Clearance of Residual Stones

Parameter	*Sensitivity*	*Specificity*	*PPV*	*NPV*	*P value*
Residual stone size $<25\,mm^2$	77.6	63.7	64.08	77.38	<0.0001
Residue size $<50\,mm^2$	98.8	63.7	69.42	98.48	<0.0001
Residual stone in the pelvis	28.3	60.1	35.8	51.6	<0.009

P value <0.05 is significant; 2×2 contingency tables used.
PPV = positive predictive value; NPV = negative predictive value.

Table 5. Factors that Predict Fate of Residual Stones

			95% confidence interval	
Parameter	*Significance*	*Exp B*	*Upper*	*Lower*
History of intervention for stone	0.006	23.02	2.38	222.3
Surgeons experience	0.001	5.80	1.41	23.8
Serum creatinine	0.014	5.80	1.41	23.89
Serum uric acid	0.001	0.50	0.33	0.77
Serum calcium	0.031	1.288	1.02	1.62
Previous nephrostomy drainage	0.05	22.77	0.94	551.4
Double-J stenting	0.001	0.14	0.03	0.67
Time to presentation of residual stone	0.085	1.098	0.98	1.22
Size of residual stone	0.007	1.077	1.03	1.11

SPSS 15.0 package was used for regression analyses.

that RF in patients with renal insufficiency leads to quicker deterioration of renal function. This further stresses the importance of complete clearance of residual stones in patients with renal insufficiency.

Renal insufficiency with nephrolithiassis is multifactorial and includes renal obstruction, infection, frequent surgical interventions, and coexisting medical disease. In two of our patients with a solitary functioning kidney with RF, 1 month postprocedure, one patient presented with anuria because of an obstructing 20 mm^2 RF that had migrated from the kidney, in the other the RF passed spontaneously.

We placed a Double-J stent if the procedure was performed for an impacted upper ureteral stone, chronic renal failure, bilateral stone disease, or in a solitary functioning kidney. Multivariate analysis suggests that placing a Double-J stent facilitates passage of RF. These findings suggest that intraoperatively, if the surgeon thinks that a RF is likely to pass, Double-J stenting would be prudent.

The surgical experience of the operating surgeon also predicts the fate of RF. A senior surgeon is likely to leave smaller residual stones that are likely to pass spontaneously. A possible reason might be that the chance of complications necessitating termination of the procedure is lower with an experienced surgeon.

Traditionally, post-PCNL radiographic imaging studies have been used to detect RF. The method for detecting RF in our study was a combination of ultrasonogfraphy and plain radiography. This may have overestimated the stone-free rate by 17% to 35%. Since last year, however, we have included CT in our armamentarium for detecting residual stones.

In summary, we think that RF $<25\,mm^2$ pass spontaneously in the majority of the cases. Residual stones can be observed for 3 months postoperatively for spontaneous passage. All residual stones $>100\,mm^2$ need intervention. Placing a Double-J stent is a worthwhile exercise in patients with the possibility of residual stones. Residual stones in patients with renal insufficiency, a history of intervention, and metabolic hyperactivity are unlikely to pass; these fragments warrant aggressive management intraoperatively.

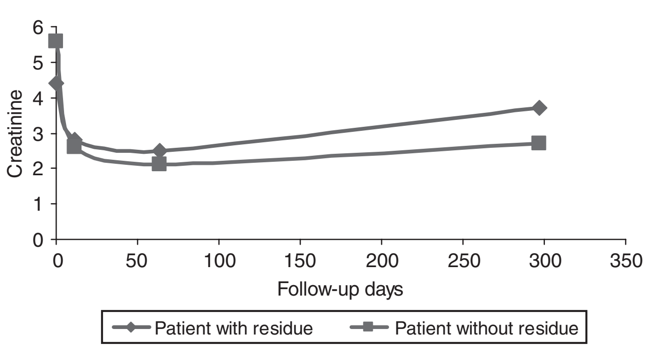

FIG. 4. Presence of RF in renal insufficiency patients leads to rapid deterioration of renal function.

Conclusions

The most common site of post-PCNL residual stones was the lower calix. Renal pelvic RF $<25\,mm^2$ have the best chance of spontaneous passage. Approximately half the RF will pass spontaneously, and the majority will clear in 3 months. The size of the residual stone, history of intervention, renal failure, and metabolic hyperactivity are predictors of persistence of RF.

Disclosure Statement

No competing financial interests exist.

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Abbreviations Used

CIRF = clinically insignificant residual fragments
CT = computed tomography
PCNL = percutaneous nephrolithotomy
RF = residual fragments
SWL = shockwave lithotripsy