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Which Factors Affect the Spontaneous Stone Passage After Flexible Ureteroscopic Lithotripsy for Renal Stones?

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Abstract

Objectives: The aim of this study was to investigate factors predicting spontaneous stone passage after Flexible Ureteroscopic Lithotripsy (fURS) for renal stones.

Materials and Methods: This study included 239 patients with renal stones who underwent fURS using the dusting technique. The final outcome was evaluated 3 months postoperatively and the Residual Fragment status (RFs) was defined as any residual stone fragments greater than 2 mm. Univariate and multivariate analyses of possible predictive factors associated with spontaneous clearance of residual renal fragments were performed.

Results:186 patients (77.8%) had achieved an Stone-Free status (SFs) and 53 patients (22.2%) were considered with RFs. Univariate analysis showed the stone location, stone number, stone size, stone CT value, IPA degree, the presence of hydronephrosis and stone covered with purulent substance were all associated with RFs ($P<0.05$). Multivariate logistic regression analysis showed that larger stone size ($P=0.001$), multiple stones ($P=0.038$), the IPA of <45° ($P=0.035$), the presence of hydronephrosis ($P=0.045$), the stone CT value ≥ 1000 ($P=0.047$) were all significantly associated with higher rates of residual stone after fURS. The stone covered with purulent substance was found to be the strongest predictor of RFs ($P=0.027$). However, the presence of lower pole stone had no significant influence on stone clearance after fURS ($P=0.263$).

Conclusions: Stone number, stone size , an IPA of <45°, stone CT value ≥ 1000 HU, stone covered with purulent substance and presence of hydronephrosis are all predictive factors of the spontaneous clearance of residual renal fragments after fURS.

Introduction

With the significant advances of endoscopic techniques, Flexible Ureteroscopic Lithotripsy (fURS) has been performed as one of the most commonly treatment modality for renal stones [1,2]. A large number of studies have confirmed its efficacy and safety in the management of renal stones and its advantages have also been reported over the last decade, including minimally invasive, low complication rate, fast recovery and short hospital stays [3-5]. According to the latest European Association of Urology Guidelines (EUA), fURS has been recommended as the first-line therapy for renal stones less than 2 cm [6]. Even for larger stones, fURS has also been performed with highly successful outcomes in some institutions and become a viable alternative to PCNL, especially for patients with poor candidates for PCNL due to anatomic challenges or any other reasons [7,8].

However, fURS is associated with a relatively high risk of residual stone fragments due to unsuccessful postoperative stone passage, especially for lower-pole stones reported by some literature [9,10]. Such residual fragments may regrowth or cause postoperative events in some cases, which will require additional invasive interventions. This may be a potential limiting factor restricting the popularization and application of this technique. More and more attention is now being paid to this issue [11-13]. Few studies had investigated the possible factors associated with stone passage after fURS, such as renal anatomy, the size and location of stones. It would definitely help surgeons to choose optimal treatment modality preoperatively, if we could identify the factors that can accurately predict the spontaneous clearance of residual renal fragments after fURS [14-16]. Nevertheless, the factors affecting the stone passage spontaneously after fURS are not clear now.

In present study, we aim to investigate the factors that affect the spontaneous stone passage after fURS for renal stones. To our knowledge, limited data are available on this issue.

Patients and Methods

Patients

We retrospectively studied 239 patients treated with fURS for renal stones using a holmium laser system in our department between March of 2018 and January of 2021. This includes stones located at the ureteropelvic junction. Our research results were registered in our hospital clinical information system with patient consent for participation obtained prior to the procedure. All patients were used a Ureteral Access Sheath (UAS) (Proxis, Boston Scientific, MA, United States) during the procedure. The size of the UAS was 12/14Fr and the fURS was performed using the dusting technique. The pulse energy settings used 0.2-0.4 J with a frequency of 30-60 Hz giving a total power of 6-24 W. The stones were dusted into tiny pieces (≤ 2 mm) which can pass spontaneously. The patients with actively basket extraction procedures were excluded in this study. All of these patients were place a ureteral stent at the end of the procedure. The final outcome of fURS was evaluated by ultrasound and plain abdominal radiography (KUB) 3 months after the surgery.

Clinical evaluation

Residual Fragment status (RFs) was defined as any residual stone fragments greater than 2 mm were detected in the ipsilateral kidney. The stone characteristics and anatomical information of kidney were obtained on preoperative abdominal CT images, such as the IPA degree, presence of hydronephrosis, diameter of the largest target stone size, location and CT value. Preoperative patient characteristics and some operative data were also recorded, including age, gender, BMI, ureteral access sheath, stent use and stone covered with purulent substance.

Statistical analysis

Statistical analyses were carried out using the Statistical Package for the Social Sciences, version 18.0 for Windows. The continuous data were compared using Student t test and the categorical data were compared by means of the chi-squared test. A multivariate logistic regression model was also used for statistical analysis to investigate the possible factors associated with stone passage after fURS. P<0.05 was considered significant in all statistical analyses.

Results

A total of 239 patients were included in this study between March of 2018 and January of 2021. All of these patients underwent only 1 procedure. Of these, 186 patients had achieved an SFs and 53 patients were considered with RFs at 3 months postoperatively. The patient characteristics and treatment outcomes are presented in table 1. There was no statistically significant difference in patients' gender, age and BMI between the SF and non-SF groups. Univariate analysis of the clinical and operative data associated with stone-free status showed significant differences between the two groups in stone location (P=0.035), stone number (P=0.014), stone size (P<0.01), the stone CT value (P=0.032) and the IPA degrees (P=0.027). Additionally, the presence of hydronephrosis and stone covered with purulent substance were also associated with RFs (P=0.013 and 0.003, respectively). The side of the kidney where the stone is located was not associated with RFs (Table 1).

Multivariate assessment that incorporated 5 significant factors associated with RFs after fURS on univariate analysis are outlined in table 2. Logistic regression analysis showed that larger stone size (P=0.001), multiple stones (P=0.038) and the IPA of <45° (P=0.035) were all significantly associated with higher rates of RFs after fURS. The presence of hydronephrosis and the stone CT value ≥ 1000 were also found to be independent predictors for stone clearance after fURS (OR 2.15, P=0.045 and OR 2.11, P=0.047, respectively). Additionally, the stone covered with purulent substance was found to be the strongest predictor of RFs after fURS (OR 2.73, P=0.027). However, the present results showed that the presence of lower pole stone had no significant influence on stone clearance after fURS in multivariate analysis (P=0.263).

Table 1: Univariate analysis of potential factors associated with stone-free status.

	Stone Free (N=186)	Residual Stone (N=53)	P
Age (years, Mean ± SD)	46.2 ± 12.9	43.4 ± 11.4	0.159
Male, n (%)	116 (62%)	32 (60%)	0.873
BMI (kg/m^2,Mean ± SD)	23.2 ± 3.8	23.4 ± 3.8	0.844
Side, n (%)			0.523
Right	70 (37.6%)	23 (43.4%)	
Left	116 (62.4%)	30 (56.6%)	
Stone location, n (%)			0.035
Lower pole	58 (31.2%)	25 (47.2%)	
Other pole or pelvis	128 (68.8%)	28 (52.8%)	
Stone number, n (%)			0.014
Single	142 (76.3%)	31 (58.5%)	
Multiple	44 (23.7%)	22 (41.5%)	
Largest target stone size (mm)			<0.01
5-10	105 (56.5%)	15 (28.3%)	
10-20	81 (43.5%)	38 (71.7%)	
Stone CT value			0.032
<1000	130 (69.9%)	28 (52.8%)	
≥ 1000	56 (30.1%)	25 (47.2%)	
Hydronephrosis (mm)			0.013
< 30	145 (78.0%)	32 (60.4%)	
≥ 30	41 (22.0%)	21 (39.6%)	
IPA, degrees			0.017
≥ 45°	143 (76.9%)	32 (60.4%)	
<45°	43 (23.1%)	21 (39.6%)	
Stone covered with purulent substance			0.003
No	166 (89.2%)	38 (71.7%)	
Yes	20 (10.8%)	15 (28.3%)	

Discussion

With technology and experience improvements, the fURS has become a popular treatment modality for the majority of renal stones in a safe and efficient manner [1,2,6]. Despite the definition of SF is not standardized and has much different in the literature, the SF rates for fURS were both reported high and similar (range from 89% to 98%), whether it uses the basketing technique or dusting technique [17,18]. Especially for renal stones smaller than 2cm, fURS has been recommended as the first-line therapy due to its superior SF rates couple with a low complication rate [2,4,6]. However, fURS was usually reported to be associated with the potential high risk of residual stone fragments for some special patients [9,10]. Some data have clearly demonstrated that the stone fragments in the lower pole calyx may be difficult to pass spontaneously due to the gravity, especially for patients with an acute infundibulopelvic angle [16,19,20]. It has also been confirmed that the SF rates will decrease as the stone size gets larger and additional interventions may be needed in these cases. These findings suggest that fURS should not be selected in some patients to avoid postoperative stone events or secondary interventions [14,16,20]. Thus, It is so important to identify factors that can accurate predict the Spontaneous Clearance Of Residual Renal Fragments

Table 2: Multivariate Logistic regression analysis of factors associated with RF rate.

	OR (95%CI)	P Value
Largest target stone size (mm)		
5-10	Referent	---
10-20	1.30 (0.14-0.62)	0.001
Stone location		
Other pole or pelvis	Referent	---
Lower pole	1.49 (0.74-3.01)	0.263
Stone number		
Single	Referent	---
Multiple	1.68 (0.21-0.96)	0.038
Hydronephrosis (mm)		
<30	Referent	---
≥ 30	2.15 (1.02-4.54)	0.045
Stone CT value		
<1000	Referent	---
≥ 1000	2.11 (1.01-4.39)	0.047
IPA, degrees		
≥ 45°	Referent	---
<45°	1.46 (0.22-0.95)	0.035
Stone covered with purulent substance		
No	Referent	---
Yes	2.73 (1.12-6.6)	0.027

(SCRF) after fURS. It will help surgeons to choose optimal treatment options and counsel patients preoperatively, especially for patients with unfavorable predictors of SCRF. Although more and more studies have focused on this issue in recent years, the information available in this regard remains limited [14,16,21].

Many studies have focused on the impact of stone intrarenal locations on post operative stone passage after fURS. The presence of lower pole stone, a unique challenge for fURS, have been reported to be associated with poorer stone clearance rates (range from 62% to 85%) in the literatures [11,16,22]. The effect of gravity was often cited as one of the reasons. And the other possible reason was that the lower pole anatomy may preclude stone clearance even if the fragmentation was small enough. Jessen and colleagues found an acute IPA of <30° was a significant risk factor of unsuccessful postoperative stone passage, as well as the fURS failure [20]. In another report, an IPA of ≥ 45° was identified as a favorable factor predicting an SF status [23]. More and more studies have showed that the degree of IPA may be an important factor in predicting the success of fURS for lower-pole stones [10,19,20]. Based on these findings, several guidelines recommend PCNL but not fURS as the first choice for the patients with lower pole stones [6]. However, free floating fragments from any locations of kidney preoperatively may most likely fall into the lower pole after fURS. In addition, some authors suggested that the lower pole stones can be relocated to an interpolar or upper pole calyx by a nitinol basket during the operation, which will facilitate the stone fragmentation and spontaneously pass postoperatively. Thus, they stated that the stone location did not significantly affect the stone clearance after fURS [4,9,14]. In our study, we found statistically difference in stone clearance between lower pole and non lower pole stones in univariate analysis. However, the same result was not found in the multivariate analysis. The possible reason was that the broken small fragments can be flushed out of the lower pole calyces by pushing the perfusion fluid to facilitate stone clearance just like the other non lower pole stones. But consistent with previous studies, we found an IPA of <45° really a significant negative risk factor for stone clearance. An acute IPA not only lead to difficulties in accessing the lower pole with flexible ureteroscopes, but also makes it more easier for the stone fragments to fall into the lower calyx and difficult to passage. Consequently, preoperative measurements of the IPA may be needed to help physicians in predicting stone clearance for patients with fURS, particularly for the stones in the lower pole.

Stone size is also a main reason affecting successful outcome of fURS often mentioned in the studies. The overall success rates with fURS for renal stones between 2 cm and 3 cm was 95.7% and 84.6% for renal stones >3cm reported by Aboumarzouk OM, et al. [24]. Many studies supported that the larger the stone, the lower the SF rate [8,15]. In our present study, we found the stone size really a predictive indicator of the RF rate after fURS, which is not surprising. Because the field of view was frequently poor for larger stones and made it difficult for surgeons to sure that the stone is dusted small enough to pass spontaneously. Thus, it may be a better choice for these patients to use a basket to actively extract some fragments after the primary stone has been broken. Unlike previous studies, our study showed that stone number was a more stronger predictor of SCRF after fURS. One of the possible reasons was that multiple stones were usually associated with complex anatomy of the intrarenal cavity, which could lead to difficulties not only in looking for the stones and crushing them during operation, but also in stone passage after fURS.

According to the literature, another important factor that may be associated with different outcomes of stone clearance after fURS is the stone density. It can be measured in HU on Noncontrast CT (NCCT) and reflect the stone hardness [14,19]. In our present study, a stone density of ≥ 1000 HU was found to be significantly associated with stone clearance both in univariate analysis and multivariate analysis, just as shown in previous studies. A proposed explanation for this observation is that the stones with a medium density of >1000 HU on NCCT, usually composed of calcium oxalate monohydrate or cystine, are particularly hard. These stones are difficult to fracture into fragments less than 3mm which are more likely to deposited in the renal calyces due to the specific gravity and not easy to be washed out by urine. Furthermore, the shape of the fragments is usually irregular and the edge is sharp, resulting in difficulty in pass through the ureter. Additionally, the hard stones need longer lasing time and higher power settings to slowly ablate the stone, which will increase the risk of thermal damage. The damage of pelvis mucosa will increase the viscosity of mucosa to stones, resulting in the stone fragments difficult to pass spontaneously. For these patients, the use of a basket during the procedure or PCNL may be a better choice, especially for patients with large renal stones.

In the present study, we found the presence of hydronephrosis was also an independent predictive factor for stone clearance after fURS. To our knowledge, the presence of hydronephrosis indicates poor renal function and a large intrarenal cavity. It is difficult to find and remove a stone in such a large space during surgical intervention [16,19]. The stone fragments were also easy to deposit in these cavities and difficult to spontaneously passage due to a lack of adequate urine flushing. Moreover, our results showed that the stone covered with purulent substance had an important predictive value on stone clearance too. The possible reason was that the small stone fragments will soon be covered by purulent substance after the stones are dusted into fragments, which will make it fail to pass. In our experiences, the stones covered with purulent substance should be broken and retrieved by baskets as much as possible.

There are some limitations in our study. First, this is a single center study with relatively small sample size, which may cause selection bias and mask the statistical significance of important differences. Second, the patients used KUB and ultrasound to evaluate postoperative residual fragment rather than CT, which may result in some detection bias. Third, this was a short follow-up study, which can only reflect early stone history after fURS.

Conclusion

Stone number, stone size, an IPA of <45°, stone density ≥ 1000 HU, stone covered with purulent substance and presence of hydronephrosis are all predictive factors of the spontaneous clearance of residual renal fragments after fURS. However, future multi-centre studies with larger sample size and longer follow-up may be needed to better support our findings.

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Author's Contribution Statement

NaiKai Liao: Project development, Data Collection, Manuscript writing

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GuangLin Yang: Data collection, Data management

ShuBo Yang: Data collection, Data analysis

GaoQiang Zhai: Data management

ChengYang Li: Project development

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Ethical Approval

The study was approved by the ethical committee of first affiliated hospital of Guangxi Medical University. All procedures performed in this study were in accordance with the ethical standards of the national research committee and with the 1964 Helsinki declaration and its later amendments.

Consent for Publication

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest from any of the authors.

Author Disclosure Statement

No competing financial interests exist.

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