The stone density does not affect the stone-free rate of kidney pelvic stones (2-3 cm) treated with flexible ureterorenoscopy

Yao Bai

Xiangya Hospital Central South University <https://orcid.org/0000-0002-3396-4442>

Sheng Hu

Xiangya Hospital Central South University

Yuanqing Dai

Xiangya Hospital Central South University

Xiong Chen

Xiangya Hospital Central South University

Xiaobo Zhang

Xiangya Hospital Central South University

Jie Gu (✉ wwkso@csu.edu.cn)

<https://orcid.org/0000-0003-2104-9367>

Research article

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Abstract

Objectives

To compare the efficacy of retrograde flexible ureterorenoscopy (FURS) in the treatment of low-density stone (LDS) and high-density stone (HDS).

Patients and Methods

From January 2017 to March 2019, 241 patients with 2–3 cm kidney pelvic stones were treated with retrograde flexible ureterorenoscopy. The relevant study parameter for all patients, including patients age, body mass index (BMI), gender, stone density values (Hounsfield units [HU]), stone size, stone location, operative time, hospitalization time, stone free rate (SFR), complications were evaluated. The results were assessed one month after the FURS and the follow-up time is 6 months.

Results

Effectively, 241 patients finish the whole process and are divided into two groups (LDS and HDS). The postoperative hemoglobin (Hb) was 13.31 ± 1.06 vs. 13.21 ± 1.14 g/dL ($p=0.50$). The mean total operating time was 83.91 ± 13.7 vs. 130.65 ± 19.8 min ($p<0.01$), respectively. The hospitalization time was 3.4 ± 1.1 vs. 3.2 ± 1.1 days ($p=0.33$), respectively. The free stone rate was 91.5% vs. 93.5% ($p=0.54$) and the street stone rate was 12(10%) vs. 3(2.4%) ($\chi^2=6.173$ a , $p=0.01$) in the LDS and HDS groups.

Conclusions

We concluded that FURS is safe and effective for the treatment of large renal pelvic stones 2-3 cm. There is no difference in the SFR between LDS and HDS group after the FURS operation. Density (as measured by non-contrast CT) of the renal calculus can help predict the treatment outcome before FURS. For appropriate patients, FURS should be chosen as a common approach in the treatment of renal pelvic calculus.

Background

Nephrolithiasis are common in all over the world and the prevalence and morbidity of this disease are increasing over the past decades [1]. A number of techniques have been described for the treatment of renal stones, including shock wave lithotripsy (SWL), retrograde flexible ureterorenoscopy and percutaneous nephrolithotomy (PCNL) [2]–[5]. Such approaches have their own advantages and disadvantages; PCNL is recommended as the gold standard for renal calculi larger than 2.0cm, due to the higher stone-free rate [6] [7]. FURS is considered to be the perfect way to treat kidney stones due to its low invasiveness, small damage and high SFR. With the improvement of lithotripsy techniques (YAG laser), SFR was further enhanced [8]. But because of the stone density and the limitation of operating time, with one operation, we still can't crush all the stones. The cost of treating stone disease is expected to increase by \$1.24 billion per year by 2030 due to population growth and the prevalence of kidney stones [1], [9].

How about the efficacy of FURS in the treatment of different density kidney pelvic stones? can we speculate something that is helpful to the patients through the stone density before the operation?

Non-contrast CT (NCCT) and kidney, ureter, and bladder (KUB) X-ray have become standard examinations for patients with kidney stones [10]–[13]. New ESWL performance predictors are identified with the data provided by the NCCT [14]. One study [15] showed that stones with a density of > 1000 HU are less likely to disintegrate. However, no published paper demonstrates the efficacy of FURS in the treatment of different density kidney pelvic stones (measured stone density by NCCT).

The purpose of this study is to compare the results of kidney pelvic stones between LDS group and HDS group that are treated with FURS.

Methods

Initially, from January 2017 to March 2019, 300 patients who received FURS in our organization were included in our study and 241 patients were included in the final post-screening analysis shown in figure 1. Criteria for inclusion: age >18 years, unilateral kidney pelvic stone 2-3 cm, normal body mass index. Exclusion criteria: no operative contraindications, moderate and severe hydronephrosis, renal anatomy abnormality.

Preoperative NCCT and KUB have been implemented for all patients. Patients' related statistical parameters, including age, BMI, gender, NCCT value (Hounsfield units [HU]), size and location of the calculi were recorded. Preoperative routine laboratory tests, including serum creatinine, coagulation screen, sterile urine culture, have been completed previous to operation. If the culture of the urine is found to be positive before surgery, or if the blood test shows signs of infection, anti-infective treatment will be given, and surgery will be performed after infection control. The density of the stone is the average of three points measured at that location as shown in figure 2. Stone size was evaluated based on European Association of Urology guidelines [16]. Remaining fragments of stone <3 mm was considered free-stone and successful treatment.

FURS technique

A normal FURS operation was carried out on all patients [17]. After general anesthesia in the lithotomy, a safety guide wire (Cook) is placed in the kidney. 9.5F semirigid ureteroscope (Germany) was performed to inspect the ureter and ureteropelvic junction in all patients. Ureteral access sheath was routinely inserted into the renal pelvis under the guidance of guide wire. FURS was performed using URF P-5 flexible ureterorenoscopy (Olympus, Tokyo, Japan) and a 200µm YAG lasers. We used a holmium laser machine (Trimeddyne, America) with an energy of 0.8 J and a rate of 25 Hz, with a total power of 20 Hz. When we disintegrate the stone at the beginning, we will disintegrate the stone slowly from the edge, instead of disintegrating it into a few smaller stones, then crushing it in pieces, because the stones are not easy to fix when they are small, so it's very difficult to crush them later. In the end, a modified basket (Cook) was

used to retrieve fragments larger than 3 mm. 6 F double-J (D-J) stents were placed in all patients and removed at the appropriate time. The operation was carried out by the same person, Professor Zhang.

Statistical analysis

The data is shown as a mean $\pm$ standard deviation (SD). The study data was analyzed using SPSS23.0. Differences in categorical data between groups were tested using χ^2 . For the evaluation of continuous variables, the Student's t test was used, statistical significance was defined as $P < 0.05$.

Results

The preoperative parameters of 241 patients were shown in Table 1. According to the density of the stones, we divide the patients into two groups, LDS group ($HU < 1000$) and HDS group ($HU \geq 1000$), respectively. These two groups have similar basic parameters, including age, gender, BMI and stone size.

Following one month of operation, post-operative X-rays and kidney ultrasound were assessed for SFR, if they had no evidence of stones or residual fragments of less than 3 mm, the operation was considered to be a success. As is shown in table2, in all, 223 (92.5%) patients were stone-free and 18 (7%) had residual fragment after treatment with FURS at one month. These two groups have a similar SFR, HDS group (93.5%) and LDS group (91.5%), respectively.

Although operating time in the HDS group was significantly longer, they had similar hospitalization time and cost for the entire operation. The LDS group had a higher street stone formation than the HDS group. During the follow-up, we found that the LDS group had to keep the D-J stent longer, with an average time of 28 days. Of course, this will increase the feeling of discomfort in the lower abdomen of these patients.

As shown in table 3, complications were assessed by the improved Clavien grading system as previous described [18]. In LDS group, 14 patients with fever ($>38^{\circ}\text{C}$), 8 patients with elevated SCr elevation (>0.5 mg/dl), 4 patients urinary tract infection, 3 patients infections requiring additional antibiotics and 12 patients with ureteric calculus. In HDS group, 21 patients with fever ($>38^{\circ}\text{C}$), 6 patients with elevated SCr elevation (>0.5 mg/dl), 3 patients with urinary tract infection 5 patients infections requiring additional antibiotics and 3 patients with ureteric calculus. All patients with fever, infection and elevated SCr are returned to normal after a few days, and no serious complications happened.

After three months of operation, 5 out of 12 and 2 out of 3 patients with ureteric calculus received ureteroscopy in the LDS group and HDS group, respectively. No new complications have arisen.

Discussion

PCNL was considered to be the best way to tackle large renal stones, regardless of its success rate of operation or its higher SFR [19]–[21]. However, in a large number of recent studies, we have observed that severe complications following PCNL are being reported such as fever, sepsis, hemorrhage requiring

blood transfusion and pneumothorax [22], [23] [24]. Lots of scholars reported that some patients are poor medical candidates for PCNL [25], [26]. They need to disintegrate the stone with the FURS. In my study, FURS was performed with 2-3 cm kidney pelvic stone and the results of this method were compared between the LDS group and the HDS group. The stone density measured by the NCCT and the patients were divided into two groups (LDS group: $HU < 1000$, HDS group: $HU \geq 1000$) depending on the stone density. Our results showed that there was no significant difference between the two groups in terms of postoperative HB level, hospitalization time, stone-free rate and retreatment rate. However, the mean total operating time is apparently longer in the LDS group, and this group also has more ureteric calculus.

FURS has been gradually accepted by patients and doctors in the treatment of larger renal stones (≥ 2 cm) as it can achieve a satisfactory free stone rate but rarely complications [27]. Because of some patients who cannot tolerate PCNL, the introduction of a new generation of YAG laser or thulium fiber laser and the development of endoscopic technology. FURS is the most attractive option for bigger kidney stones. The success rate for FURS may depend on many factors, such as the location of stone, size, density, years, gender, side and BMI. Pervious, One study showed that the total average operating time in the hard stones group was significantly longer [27]. However, in our study, the results were compared between the LDS group and the HDS group, showing that the total operating time in the LDS group is significantly longer. These two outcomes are the opposite. There may be a variety of reasons. First of all, the equipment used in each operating room is different. In this study, the latest Holmium laser and FURS were used to ensure the efficiency of the lithotripsy process. Secondly, the surgeon's experience is important as well. Unexperienced doctors break the stones rapidly into small pieces and crush them one after another (Figure 3A). However, our approach is to break the stone slowly from the edge of the stone, just like peeling (Figure 3B). Of course, when the stones get smaller, it's a bit difficult. Why does our result show that the LDS Group's operating time is significantly longer? Not hard stone is easily broken into a few large pieces in a short time, and then, due to its flexible mobility, it is hard to keep breaking and take longer to remove fragments using a stone basket. Because of the compactness of the hard stone, as the ants eat, the surgeon can break the stone into small particles, and only little fragments need to be removed by a stone basket. That's why we're using a very short operating time in the HDS group.

Stone Street is a common complication for the three different ways (SWL, PCNL and FURS) to disintegrate the stone [7], [28]. Normally after dealing with laser, some large fragments still need to be removed by a stone basket but we cannot remove all of them, the remaining stones will be eliminate along the ureter, and of course, we will keep the D-J ureteral stent to minimize the formation of stone streets. One study showed that stone street occurs in approximately 15% of cases after ESWL [29]. The incidence of this phenomenon will be relatively lower following the operation of PCNL and FURS. In this study, we found that the stone street incidence of the LDS group (10%) was higher than the HDS group (2.4%). Because more smaller fragments are formed in the LDS group during the stone disintegrating process. In consistent with this, we found that we need to keep the D-J stent longer in the LDS group to make sure that the stone can be eliminated from the ureter (Group LDS vs Group HDS: 28 vs 21 days).

The limitation of this study is the less-sample nature of its design, a single-surgeon, a retrospective nature, and single-center design. CT value 1000HU is certainly an appropriate relative value that more is required to acquire a comparatively credible value through more clinical data.

Conclusion

FURS is safe and effective for the treatment of large kidney stones. It has been confirmed that the use of NCCT to measure renal stone density before FURS helps to predict the outcome of the treatment. FURS should be decided as a common approach in the treatment of kidney pelvic stones > 2 cm for preferred patients. Low-density stones need longer total operating time and result in more stone streets and need to keep D-J stent longer.

Abbreviations

Flexible ureterorenoscopy: FURS

Low-density stone: LDS

High-density stone: HDS

Stone free rate: SFR

Postoperative hemoglobin: Hb

Kidney, Ureter, and Bladder: KUB

Non-contrast computed tomography: NCCT

Hounsfield units: HU

Body mass index: BMI

Percutaneous nephrolithotomy: PCNL

Shock wave lithotripsy: SWL

Declarations

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Ethics approval and consent to participate: The study was approved by the Ethics Committee of the Xiangya Hospital of Central South University.

Informed consent: All patients in this study signed an informed consent form before operation.

Consent for publication: Not Applicable

Availability of data and materials: The datasets generated and analysed during the current study are not publicly available due to our project are not finished completely but are available from the corresponding author on reasonable request.

Authors Contributions

Y B: Project development, Data analysis, Manuscript writing/editing.

H S: Data Collection.

YQ D: Data analysis.

X C: Data analysis.

XB Z: Project development, Manuscript writing.

J G: Data Collection, Manuscript writing.

All authors have read and approved the manuscript and ensure that this is the case.

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Tables

Table1 Preoperative parameters of 241 patients			
Variable	Low-density stone group (HU)	High-density stone group (HU)	P-value
Patients (No.)	117	124	-
Gender			0.33
Male	63	59	-
Female	54	65	-
Side			0.87
Right	55	57	-
Left	62	67	-
Mean (SD)			
Age, years	51±10.4	50±10.9	0.68
BMI, Kg/m ²	21.4±1.6	21.8±1.4	0.11
Stone size, cm	2.4±0.2	2.5±0.2	0.15
Stone location			
Upper/mid calyceal	0	0	-
Renal pelvic	117	124	-
Lower calyceal	0	0	-

Table 2 Univariate analysis after FURS at one month			
Variable	Low-density stone group (HU)	High-density stone group (HU)	P-value
Postoperative Hb level (g/dL)	13.31±1.06	13.21±1.14	0.50
Mean total operative time (min)	83.91±13.7	130.65±19.8	<0.01
Hospitalization time (day)	3.4±1.1	3.2±1.1	0.33
Stone free rate, n/N (%)	107/117(91.5)	116/124(93.5)	0.54
Retreatment rate, n/N (%)	2/117 (1.7)	2/124 (1.6)	0.95
Complications			
Fever	22(19%)	27(22%)	0.57
Stone street	12(10%)	3(2.4%)	0.01
Hb: hemoglobin			

Table 3 Classification of lower stone density group and higher stone density group complications according to the modified Clavien grading system			
Grade of complication	Low-density stone group (HU)	High-density stone group (HU)	P-value
I	22	27	0.57
II	7	8	0.88
III			
A	0	0	-
B	12	3	0.01
IV			
A	0	0	-
B	0	0	-
V	0	0	-
Total	41	38	

Figures

Figure 1

CONSORT follow-up chart for study participants

Figure 2

Stone location where the density was measured. Kidney pelvic stones labeled with a red arrow

Figure 3

Stone disintegrating effect diagram Low-density stones crack into large pieces(A), but high-density stones crack into small particles(B).