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Predicting Risk Factors Affecting the Efficacy of Flexible Ureteral Holmium Laser Lithotripsy and Extracorporeal Shock Wave Lithotripsy for Ureteral Calculi Based on Decision Tree Model

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AIM: To evaluate the efficacy of flexible ureteroscopic lithotripsy (FURL) and extracorporeal shock wave lithotripsy (ESWL) in the treatment of ureteral calculi based on decision tree model.

METHODS: A total of 600 patients with ureteral calculi, including 289 treated with FURL and 311 cases with ESWL in Anqing Municipal Hospital from June 2021 to August 2023, were selected as study subjects. Perioperative indicators and stone clearance rate of the two groups were compared, and the preoperative and postoperative (24 and 72 hours) changes of serum creatinine, cystatin C (Cys-C) and microalbumin were observed. The complications during and 7 days after treatment, the influence of perioperative indexes, total stone removal rate and renal function indexes were analyzed using decision tree method, and a complication risk prediction model was constructed.

RESULTS: The operation time, length of hospital stays and postoperative hematuria time in FURL group were shorter than those in ESWL group ($p < 0.001$), and the usage of painkillers was less frequent in FURL group than in ESWL group ($p = 0.002$). The total stone removal rate in the FURL group was higher than that in the ESWL group ($p < 0.001$). Serum creatinine, urinary microalbumin and Cys-C in both groups were lower before surgery than at 24 h and 72 h after surgery ($p < 0.05$). Serum creatinine, urinary microalbumin and Cys-C in FURL group were lower than those in the ESWL group at 24 and 72 h after operation ($p < 0.001$). The overall complication rate in the FURL group was lower than that in the ESWL group ($p = 0.028$). Decision tree model analysis showed that four explanatory variables, including preoperative creatinine, urinary microalbumin, Cys-C and surgical method were identified by screening. The risk statistic of the model was 0.027, and the accuracy, sensitivity and specificity of the model in predicting postoperative complications in patients with ureteral calculi were 97.33%, 97.73% and 97.30%, respectively.

CONCLUSIONS: FURL has significant advantages over ESWL in the treatment of ureteral calculi, and has less impact on renal function and fewer complications. Preoperative creatinine, urinary microalbumin, Cys-C and surgical methods may adversely influence the occurrence of postoperative complications. These identified factors can be employed to build a decision tree model for predicting the occurrence of postoperative complications.

Keywords: decision tree model; flexible ureteroscopic lithotripsy; extracorporeal shock wave lithotripsy; ureteral calculus

Introduction

Ureteral calculus is a common type of stone found in the urinary system. At present, the mechanisms behind the occurrence of this condition are not yet fully clarified, but it is believed that several factors such as diet, metabolic abnormalities, genetics, and medication contribute to its occurrence [1]. Some procedures, such as flexible ureteroscopic lithotripsy (FURL) and extracorporeal shock wave lithotripsy (ESWL), which are noninvasive, are the primary clinical treatment for ureteral calculus [2]. FURL employs a flexible ureteroscope to directly observe and localize the stones, and uses holmium laser to precisely break them after localization, featuring high efficiency and accuracy, among other merits. ESWL utilizes high-energy shock waves to shatter the stones, presenting advantages such as simple operation and rapid recovery. However, study has indicated that these surgical methods may lead to a series of complications, including bladder irritability, ureteral perforation, and low back pain [3].

Decision tree models have been widely utilized in clinical settings for endpoint event risk assessment and prediction by virtue of their ability to integrate multiple indicators and simulate decision-making processes by constructing tree-like structures, thus facilitating variable selection. For example, they have been applied to assess the postoperative recurrence risk in patients with urinary system stones and to predict adverse events following emergency percutaneous coronary intervention [4,5]. Currently, there are limited reports in the clinical literature on the use of decision tree models to evaluate the effectiveness of different surgical methods. In light of the aforementioned shortcomings sur-

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Table 1. Comparison of baseline characteristics between the FURL and ESWL groups.

Groups	Gender, *n* (%)		Age (years)	BMI (kg/m^2)	Stone side, *n* (%)		Stone size (cm)	Stone location, *n* (%)	
	Male	Female			Right	Left		Upper segment	Middle and lower segment
FURL group (*n* = 289)	146 (50.52)	143 (49.48)	39.94 ± 2.08	23.96 ± 1.82	149 (51.56)	140 (48.44)	0.91 ± 0.16	118 (40.83)	171 (59.17)
ESWL group (*n* = 311)	151 (48.55)	160 (51.45)	40.11 ± 2.13	24.05 ± 1.75	156 (50.16)	155 (49.84)	0.89 ± 0.18	112 (36.01)	199 (63.99)
χ^2/t	0.232		0.989	0.617	0.117		1.441	1.471	
p	0.630		0.323	0.537	0.732		0.150	0.225	

Abbreviations: ESWL, extracorporeal shock wave lithotripsy; FURL, flexible ureteroscopic lithotripsy; BMI, body mass index.

Table 2. Perioperative indicators between the FURL and ESWL groups.

Groups	Operation time (min)	Length of hospital stays (d)	Postoperative hematuria time (d)	Painkiller usage rate (*n*, %)
FURL group (*n* = 289)	35.47 ± 2.74	6.09 ± 1.27	1.81 ± 0.32	43 (14.88)
ESWL group (*n* = 311)	53.09 ± 3.80	7.98 ± 1.52	2.39 ± 0.57	78 (25.08)
χ^2/t	65.48	16.57	15.507	9.683
p	$<$0.001	$<$0.001	$<$0.001	0.002

Abbreviations: ESWL, extracorporeal shock wave lithotripsy; FURL, flexible ureteroscopic lithotripsy.

rounding the treatment of ureteral stones with FURL and ESWL, this study constructs a decision tree model to assess the therapeutic outcomes of FURL versus ESWL.

Materials and Methods

Study Subjects

A total of 600 patients with ureteral calculi were selected, including 289 treated with FURL and 311 cases treated with ESWL, all of whom were treated at Anqing Municipal Hospital between June 2021 and August 2023. Patients with the following conditions were included: (i) diagnosed with unilateral ureteral calculus via ultrasound or computed tomography (CT); (ii) stone diameter between 0.7 and 1.5 cm; and (iii) age of patient between 18 and 65 years. Exclusion criteria for this study are as follows: (i) patients with ureteral strictures; (ii) patients with malignant tumors; and (iii) patients with acute or chronic pyelonephritis or glomerulonephritis. This study complied with the principles of the Declaration of Helsinki, and informed consent was obtained from patients and their families. This study was approved by the Ethics Committee of Anqing Municipal Hospital (ethical batch number: Medical Ethics Review (2024) No. 100).

Methods

Methods of Data Collection

A standardized questionnaire was utilized to gather clinical information including gender, age, body mass index (BMI), stone side, stone size, stone location, perioperative indicators (operation time, hospital stays, postoperative hematuria time, and painkiller usage rate), stone clearance rate, renal function parameters (serum creatinine, urinary microalbuminuria, cystatin C [Cys-C]), and incidence of complications.

Methods of Treatment

The ESWL group was treated using the extracorporeal shock wave lithotripter (HK. ESWL-V, Huikang Medical Apparatus Co. Ltd., Shenzhen, Guangdong, China). Patient positioning was dictated by the location of calculus, which was determined via ultrasound localization: supine for upper ureteral calculus, prone for mid-ureteral, and a combination of supine and prone for lower ureteral. The parameters for operating the lithotripter include a voltage of 11–18 KV, and shock counts ranging from 1500 to 4000 times. Ultrasound examinations were performed 3 to 7 days after lithotripsy. If lithotripsy failed, no more than three sessions of treatments could be repeated 1 to 2 weeks later. Postoperatively, routine anti-infection treatment was administered. In the FURL group, the treatment was given using a Versa Pulse Powersuit 100 W holmium laser device (Cook Medical, Bloomington, IN, USA). After general anesthesia, the patient was placed in the bladder lithotomy position, and a hydrophilic guidewire, a flexible ureteroscope sheath, and a flexible ureteroscope were inserted into the ureter. The intraluminal stones were located, and a holmium laser fiber was inserted. Pulsed energy was set to 0.8 J with a frequency of 10 Hz to fragment the stones. Success was determined when the stones were reduced to less than 2 mm. For larger stones or those adhered to the ureteral wall, forceps were used for stone removal. After completing the surgical procedure, a ureteral stent was placed, and routine anti-inflammatory treatment was provided postoperatively.

Table 3. Comparison of stone clearance rates between the FURL and ESWL groups.

Groups	n	Location of ureteral calculus		Total clearance rate
		Upper segment	Middle and lower segment	
FURL group	289	88.14 (104/118)	98.25 (168/171)	94.12 (272/289)
ESWL group	311	87.50 (98/112)	65.83 (131/199)	73.63 (229/311)
χ^2		0.022	62.324	45.622
p		0.883	$<$0.001	$<$0.001

Note: Data are expressed as percentages followed by count in ratio.

Abbreviations: ESWL, extracorporeal shock wave lithotripsy; FURL, flexible ureteroscopic lithotripsy.

Observation Indicators

(1) Perioperative indicators such as the operation time, length of hospital stays, duration of postoperative hematuria, and the usage rate of analgesics for both groups of patients were recorded.

(2) B-super ultrasound examination of the urinary system was conducted 3 months postoperatively to assess stone clearance, with the absence of calculus or residual calculus with a diameter of less than 5 mm in the ureter indicating successful stone clearance.

(3) Renal function was assessed. From each fasting patient, 3 mL of venous blood was collected before surgery and at 24 h and 72 h postoperatively. The samples were centrifuged at 3000 r/min for 10 minutes to obtain the supernatant, and creatinine and Cys-C levels were measured subsequently using the automatic biochemical analyzer (AS-1450, Ailex technology, Shanghai, China). Additionally, 24-hour urine samples were collected at the same time points to measure microalbumin level using the scattering turbidimetric method.

(4) The occurrence of complications such as fever, bladder irritability, low back pain, septic shock, ureteral perforation, stent displacement, or other complications was recorded during the surgical treatment and within 7 days postoperatively for both groups of patients.

Statistical Methods

The data were analyzed using SPSS 22.0 software (Version 22.0, IBM SPSS statistics, Chicago, IL, USA). The Shapiro–Wilk test was conducted to assess the normality of the data collected. Normally distributed data are expressed as mean ± standard deviation ($\bar{x} \pm s$). Categorical data are expressed as count and percentage. For normally distributed data, t-tests were utilized for comparative analysis, whereas for categorical data, χ^2 tests were employed for analysis. For comparisons over multiple time points, repeated measures analysis of variance (ANOVA) was used, and pairwise comparisons were performed using the least significant difference (LSD) post-hoc test. The decision tree method was employed to analyze the impact of perioperative indicators, total stone clearance rate, and preoperative renal function parameters on the occurrence of postoperative complications, leading to the construction of a complication risk prediction model. p-value < 0.05 was considered statistically significant.

Results

Baseline Characteristics

The comparison of baseline characteristics between the two groups showed no statistically significant difference ($p >$ 0.05, Table 1).

Perioperative Indicators

The operation time, length of hospital stays, and postoperative hematuria time in the FURL group were all shorter than those in the ESWL group ($p < 0.001$), and the usage of painkiller was less frequent in the FURL group compared to the ESWL group ($p < 0.01$, Table 2).

Stone Clearance Rate

The total stone clearance rate in the FURL group was higher than that in the ESWL group ($p < 0.001$, Table 3).

Comparison of Renal Function

Compared to preoperative levels, both the FURL and ESWL groups showed an increase in serum creatinine, urinary microalbumin, and Cys-C levels at 24 h and 72 h postoperatively ($p < 0.05$). At 24 h and 72 h postoperatively, the FURL group had lower serum creatinine, urinary microalbumin, and Cys-C levels than the ESWL group ($p <$ 0.001, Table 4).

Comparison of Complications

The overall incidence of complications in the FURL group was lower than that in the ESWL group ($p < 0.05$, Table 5).

Decision Tree Model

Using complications as the grouping criterion, independent samples t-tests were conducted on perioperative indicators, total stone clearance rate, and preoperative renal function indicators. The results showed that there were statistically significant differences in the comparisons of perioperative indicators, total stone clearance rate, and renal function indicators ($p < 0.05$). The indicators that showed differences were then incorporated into the chi-squared automatic inter-

Table 4. Comparison of renal function between the FURL and ESWL groups.

Groups	Serum creatinine (µmol/L)			Urinary microalbumin (mg/24 h)			Cys-C (µg/L)		
	Preoperative	Postoperative 24 h	Postoperative 72 h	Preoperative	Postoperative 24 h	Postoperative 72 h	Preoperative	Postoperative 24 h	Postoperative 72 h
FURL group (n = 289)	71.22 ± 8.03	88.36 ± 10.74^{a}	80.42 ± 9.14^{ab}	15.32 ± 2.47	23.36 ± 3.74^{a}	19.12 ± 3.05^{a}	510.14 ± 28.96	609.82 ± 35.41^{a}	567.88 ± 30.06^{ab}
ESWL group (n = 311)	71.30 ± 7.96	96.27 ± 12.08^{a}	91.14 ± 10.26^{ab}	15.28 ± 2.50	28.77 ± 4.09^{a}	24.71 ± 3.86^{a}	510.09 ± 28.79	698.74 ± 41.28^{a}	629.61 ± 35.73^{ab}
t	0.122	8.488	13.532	0.197	16.924	19.752	0.021	28.379	22.955
p	0.903	<0.001	<0.001	0.844	<0.001	<0.001	0.983	<0.001	<0.001
F value		F time point = 1700.610, F interaction = 120.595, F inter-group = 86.124			F time point = 3932.552, F interaction = 384.506, F inter-group = 255.643			F time point = 6229.328, F interaction = 632.572, F inter-group = 471.362	
p value		F time point <0.001, F interaction <0.001, F inter-group <0.001			F time point <0.001, F interaction <0.001, F inter-group <0.001			F time point <0.001, F interaction <0.001, F inter-group <0.001	

Note: $^{a}p < 0.05$ compared with the preoperative group; $^{b}p < 0.05$ compared with the postoperative 24 h group. ESWL, extracorporeal shock wave lithotripsy; FURL, flexible ureteroscopic lithotripsy; Cys-C, cystatin C.

Table 5. Comparison of complication incidence between the FURL and ESWL groups.

Groups	Fever	Bladder irritability	Lower back pain	Septic shock	Ureteral perforation	Stent tube displacement	Overall incidence rate
FURL group (n = 289)	3 (1.04)	5 (1.73)	8 (2.77)	0	2 (0.69)	2 (0.69)	20 (6.92)
ESWL group (n = 311)	6 (1.93)	10 (3.22)	16 (5.14)	1 (0.32)	5 (1.61)	0	38 (12.22)
χ^2	-	-	-	-	-	-	4.816
p	-	-	-	-	-	-	0.028

Note: Data are expressed as counts (percentages). ESWL, extracorporeal shock wave lithotripsy; FURL, flexible ureteroscopic lithotripsy.

Table 6. Confusion matrix of decision tree model prediction results and actual results.

Observed value	Projected value		
	Complication group	Non-complication group	Positive percentage
Complication group	43	15	74.10%
Non-complication group	1	541	99.80%
Overall percentage	7.30%	92.70%	97.30%

action detector (CHAID) decision tree model, using operation time, length of hospital stays, postoperative hematuria time (all shorter than those in the ESWL group), painkiller usage rate, total stone clearance rate, as well as preoperative serum creatinine, urinary microalbumin, and Cys-C as independent variables, with the occurrence of postoperative complications as the dependent variable. The model consisted of 4 layers and a total of 8 nodes. A total of 4 explanatory variables were selected: preoperative serum creatinine, urinary microalbumin, Cys-C, and surgical method (Fig. 1). The model's risk statistic was 0.027 (16/600), with an accuracy of 97.33% (584/600), a sensitivity of 97.73% (43/44), and a specificity of 97.30% (541/556) in predicting postoperative complications in patients with ureteral calculus (Table 6).

Discussion

Affecting mostly middle-aged men, ureteral calculi represent a common clinical disease, accounting for about 48% of all cases of urinary tract calculi [6]. Clinical statistics have shown that the gender ratio of ureteral stone incidence is approximately 3~9:1 (male to female) [7]. Currently, the clinical treatment for this condition primarily involves ESWL or FURL. Among these procedures, ESWL is a noncontact and noninvasive treatment method. Compared to the traditional ureter lithotomy, this nonsurgical method mainly utilizes high-energy shock waves to break the stones, which are then expelled naturally through the urethra. However, further clinical research has found that ESWL is not applicable and suitable for all patients with ureteral stones, because the selection of ESWL lies in the stone's composition, size, and number; it is more appropriate for patients harboring stones with a diameter of $\leq$2 cm, particularly those composed of struvite (magnesium ammonium phosphate) or dihydrate calcium oxalate [8,9]. Clinical study has shown that the stone clearance rate for ESWL treatment of ureteral stones is approximately 57% to 88%, with about 15% to 50% of patients requiring additional methods for treatment or re-treatment [10]. Study has also proposed using FURL for the treatment of ureteral stones [11]. Analysis of this technique indicates that it involves the insertion of a ureteroscope through the urethra, followed by the use of holmium laser lithotripsy to fragment the stones into small particles, which are then suctioned out using the ureteroscope sheath, while leaving a ureteral stent in place to facilitate stone passage [12,13]. Compared to ureter lithotomy, FURL is superior in terms of eliciting less pain and necessitating no incisions on the body. Additionally, compared to the instruments and tools utilized in ESWL, the flexible ureteroscope used in FURL can bend freely, allowing access to various parts of the kidneys and providing a more effective lithotripsy for stone located in the lower calyx of the kidney [14]. Therefore, there has been wide adoption of FURL in clinical settings.

The results of this study showed that the total stone clearance rate in the FURL group was higher than that in the ESWL group, consistent with the findings of Gao *et al.* [15], suggesting that FURL treatment is effective in eliminating ureteral calculus. The better efficacy showcased by FURL in stone clearance may be related to the ability of the ureteroscope to directly visualize the stones, allowing for precise lithotripsy and stone retrieval under direct observation, which significantly improves the stone clearance rate [16]. Additionally, FURL features vaporization and cutting functions, enabling it to completely fragment harder cystine stones [17,18]. This study also found that the operation time, length of hospital stays, and postoperative hematuria time in the FURL group were all shorter than those in the ESWL group, and the usage of painkiller was also lower in the FURL group. These findings indicate that FURL engender less trauma and promote faster postoperative recovery in the patients. Additionally, the holmium laser can provide hemostatic effects, reducing intraoperative bleeding, which in turn shortens the duration of postoperative hematuria [19,20]. Serum creatinine, urinary microalbumin, and Cys-C are common indicators for clinically assessing renal function. This study found that serum creatinine, urinary microalbuminuria, and Cys-C levels significantly increased in both groups at 24 h and 72 h postoperatively compared to preoperative levels, suggesting that FURL and ESWL treatments may cause transient renal dysfunction, such as decreased glomerular filtration rate or tubular epithelial cell damage, primarily within the first 1–3 days post-surgery, after which their levels gradually return to normal. Further analysis of renal function markers revealed that the increases in serum creatinine, urinary microalbuminuria, and Cys-C levels were less pronounced in the FURL group compared to the ESWL group at 24 h and 72 h postoperatively. This indicates that FURL causes less renal damage than ESWL, possibly due to its shorter pulse duration, which effectively minimizes thermal injury to surrounding tissues [21,22]. Additionally, performing lithotripsy and ureteral dilation under direct visualization using the ureteroscope facilitates early restoration of urinary tract pa-

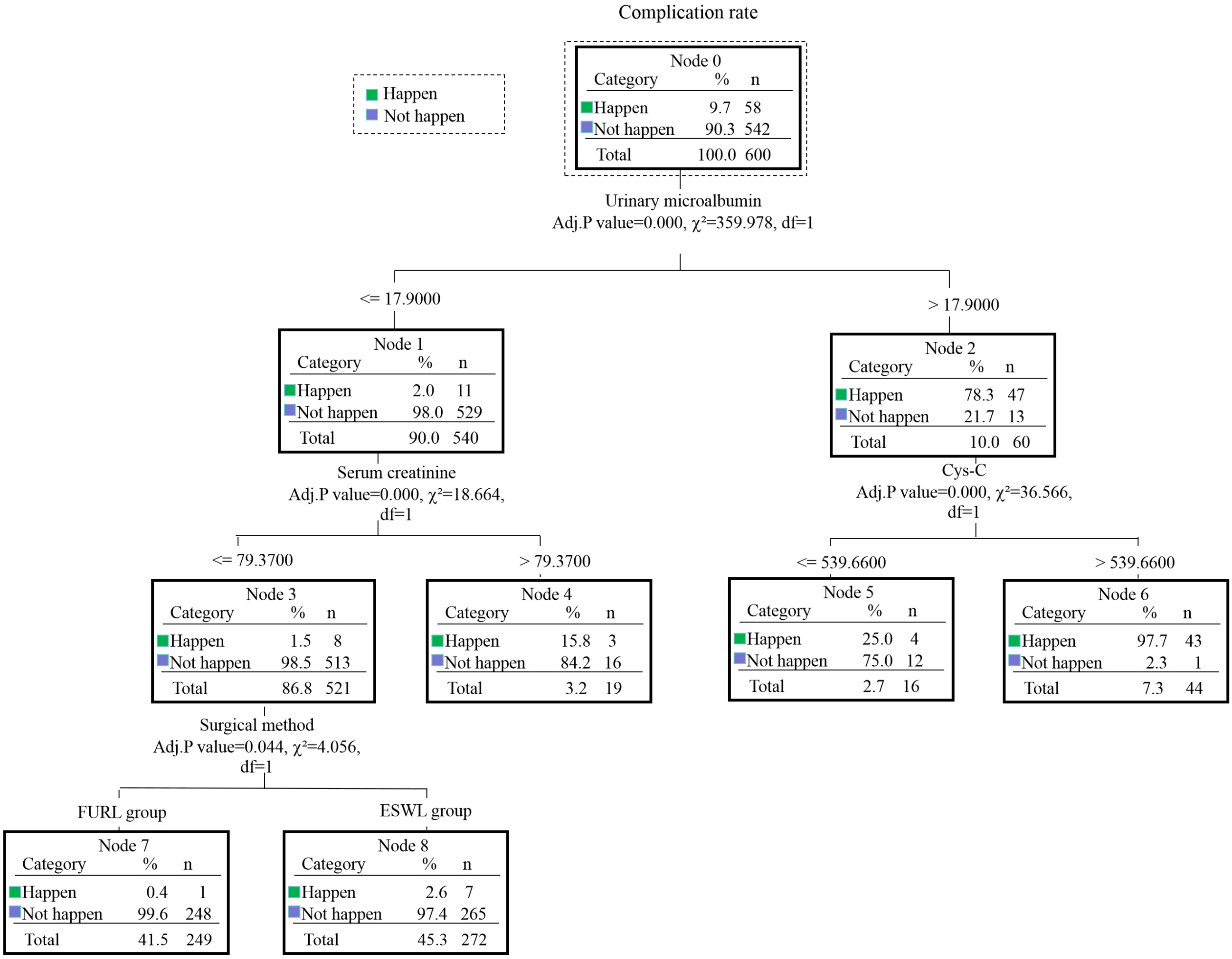

Fig. 1. Decision tree model for predicting postoperative complications in patients with ureteral calculus. Abbreviations: ESWL, extracorporeal shock wave lithotripsy; FURL, flexible ureteroscopic lithotripsy; Cys-C, cystatin C.

tency. In contrast, ESWL is associated with less effective stone fragmentation and weaker relief of ureteral obstruction [23,24]. Therefore, renal function markers were significantly higher postoperatively in the ESWL group than in the FURL group.

This study found that the overall complication rate in the FURL group was lower than that in the ESWL group, indicating the enhanced safety of FURL. However, the risk factors leading to postoperative complications in patients with ureteral stones remain unclear. Therefore, this study constructed a decision tree model for predicting the risk of developing postoperative complications such as fever, bladder irritability, lower back pain, septic shock, ureteral perforation, and stent displacement. The model compared operation time, length of hospital stays, duration of postoperative hematuria, total stone clearance rate, and preoperative serum creatinine, urinary microalbuminuria, and Cys-C levels between patients with and without complications. The parameters presenting significant differences in the previous analysis were incorporated into the CHAID decision tree model to further analyze their impact on postoperative complications. The decision tree model identified four variables, namely preoperative serum creatinine, urinary microalbumin, Cys-C, and surgical method. Analysis of these variables revealed that patients with preoperative urinary microalbuminuria >17.90 mg/24 h had the highest risk of postoperative complications, and this risk was even higher when Cys-C exceeded 539.66 µg/L. Therefore, special attention should be given to patients with these clinical anomalies.

Several shortcomings of the present study should be acknowledged. It is important to note that the retrospective nature of the study and the inclusion of all cases selected from a single center may introduce bias. Therefore, further large-scale, multicenter prospective studies are needed to validate the findings obtained in this study.

Conclusions

In conclusion, FURL has significant advantages over ESWL in the treatment of ureteral calculus, exerting minimal impact on renal function and trigger fewer complications. Preoperative levels of serum creatinine, urinary microalbumin and Cys-C, as well as the surgical method used, may negatively influence the occurrence of postoperative complications. These factors can be integrated into the construction of a decision tree model for predicting the occurrence of postoperative complications.

Availability of Data and Materials

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

BW and RZ designed the research study and wrote the first draft. LW and HH performed the research. LW, XGD and TB analyzed the data. All authors contributed to editorial important changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study complies with the principles of the Declaration of Helsinki, and informed consent was obtained from both patients and their families. This study was approved by the Ethics Committee of Anqing Municipal Hospital (ethical batch number: Medical Ethics Review (2024) No. 100).

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] Yin K, Yin Z, Liu Z, Yao J, Wu Y, Su S. Exploring the association between multiple factors and urolithiasis: A retrospective study and Mendelian randomization analysis. Medicine. 2024; 103: e37968.

[2] Testault I, Gatel L, Vanel M. Comparison of nonenhanced computed tomography and ultrasonography for detection of ureteral calculi in cats: A prospective study. Journal of Veterinary Internal Medicine. 2021; 35: 2241–2248.

[3] Tan D, Wu F, Huo W. Clinical Characteristics and Risk Factors of Systemic Inflammatory Response Syndrome after Flexible Ureteroscopic Lithotripsy. Archivos Espanoles De Urologia. 2022; 75: 618–623.

[4] Ye HJ, Zhang GF. Construction of an early warning model for postoperative recurrence risk in patients with urinary stones based on logistic regression analysis and decision tree algorithm. Journal of Minimally Invasive Urology. 2024; 13: 160–166. (In Chinese)

[5] Liu ZY, Kong YW, Zhang YH, Zhang YH, Wang Z, Lu XY, *et al.* Predictive value of decision tree model for postoperative adverse events in patients undergoing emergency PCI for diabetes mellitus combined with acute myocardial infarction. Chinese Journal of Evidence-Based Cardiovascular Medicine. 2022; 14: 1334–1340. (In Chinese)

[6] Li M, Zhang H, Jiang D, Li L, Liu X, Zhao X, *et al.* Calculus-related functional protein expression in ureteral calculus-adhered polyp: A preliminary study. Medicine. 2021; 100: e26512.

[7] Qi Y, Xing H, Yang S, Peng Z, Chen Y, Qi S. Antegrade flexible ureteroscopy-assisted percutaneous nephrolithotomy for staghorn calculi: a prospective randomized controlled study. Urolithiasis. 2024; 52: 33.

[8] Caglar U, Erbin A, Ucpinar B, Ayranci A, Sarilar O, Yanaral F, *et al.* Failed insertion of ureteral access sheath during flexible ureterorenoscopy: a randomized controlled trial comparing second session flexible ureterorenoscopy or same session mini percutaneous nephrolithotomy. International Urology and Nephrology. 2024; 56: 433–439.

[9] Hosseini SR, Tehranipour E, Khadem A, Alwedaie SMJ. Three-Dimensional Virtual Reconstruction Method versus Standard Fluoroscopy as a Guiding Tool for an Optimal Puncture Rout in Patients Undergoing Percutaneous Nephrolithotomy: A Randomized Trial Study. Urology Journal. 2024; 21: 29–34.

[10] Zeng X, Diao X, Jin S, Hu W, Bai W, Li J, *et al.* Needle-perc-assisted endoscopic surgery (NAES) for patients with complicated solitary kidney stones: a prospective randomized study from a single center. World Journal of Urology. 2023; 41: 3121–3127.

[11] Wu G, Ying X, Shen C, Gao K, Ren Y, Luo Z. Analysis of the Efficacy and Safety of PCNL and ESWL in Patients with Complicated Upper Urinary Tract Renal Calculi. Alternative Therapies in Health and Medicine. 2023; 29: 760–763.

[12] Li ZG, Zhao Y, Fan T, Hao L, Han CH, Zang GH. Clinical effects of FURL and PCNL with holmium laser for the treatment of kidney stones. Experimental and Therapeutic Medicine. 2016; 12: 3653–3657.

[13] Jiao B, Lai S, Xu X, Zhang M, Diao T, Zhang G. The efficacy of flexible ureteroscopy lithotripsy and miniaturized percutaneous nephrolithotomy for the treatment of renal and proximal ureteral calculi of ≤ 2 cm: A retrospective study. Medicine. 2019; 98: e14535.

[14] Safdari A, Khazaei S, Biglarkhani M, Mousavibahar SH, Borzou SR. Effect of acupressure on pain intensity and physiological indices in patients undergoing extracorporeal shock wave lithotripsy: a randomized double-blind sham-controlled clinical trial. BMC Complementary Medicine and Therapies. 2024; 24: 55.

[15] Gao J, Wang X, Xu X, Luo ZJ, Wang L. Comparison of therapeutic effects between ureteroscopic holmium laser lithotripsy and extracorporeal shock wave lithotripsy for the treatment of ureteral stones. Modern Journal of Integrated Traditional Chinese and Western Medicine. 2020; 29: 2098–2102. (In Chinese)

[16] Blachutzik F, Meier S, Weissner M, Schlattner S, Gori T, Ullrich H, *et al.* Coronary intravascular lithotripsy and rotational atherectomy for severely calcified stenosis: Results from the ROTA.shock trial. Catheterization and Cardiovascular Interventions: Official Journal of the Society for Cardiac Angiography & Interventions. 2023; 102: 823–833.

[17] Ding Q, Zhu H, Fan Z, Li F, Tu W, Jin X, *et al.* Comparative Analysis of Super-Mini Percutaneous Nephrolithotomy Combined with Flexible Ureteroscopic Lithotripsy versus Flexible Ureteroscopic Lithotripsy Alone for Treating Complex Kidney Stones: A Retrospective Study of 205 Patients. Medical Science Monitor: International Medical Journal of Experimental and Clinical Research. 2023; 29: e941012.

[18] Ziaei Azarkhavarani F, Rejeh N, Valiani M, Kazemi R. Effect of acupressure on pain among older female patients undergoing extracorporeal shock wave lithotripsy: A randomized controlled clinical trial. Explore (New York, N.Y.). 2024; 20: 233–238.

[19] Mohey A, Abdelfattah AA, Mohammed AE, Marzouk A, El-Dakhakhny AS. Comparative study between antegrade flexible

ureteroscopy and reterograde intrarenal surgery in the management of impacted upper ureteric stones 1.5 cm or larger. World Journal of Urology. 2023; 41: 3731–3736.

[20] Karaaslan M, Olcucuoglu E, Kurtbeyoglu S, Tonyali S, Yilmaz M, Odabas O. Erector spinae plane block prior to extracorporeal shock wave lithotripsy decreases fluoroscopy time and promise a comfortable procedure for renal stones: A prospective randomized study. Actas Urologicas Espanolas. 2023; 47: 566–572.

[21] Sajjad K, Shahid MA, Ali M, Hayat K, Nazir M. Stone clearance and complication rate of micro percutaneous nephrolithotomy and retrograde intrarenal surgery for lower pole renal stone: A randomized trial. Journal of Ayub Medical College, Abbottabad: JAMC. 2023; 35: S721–S725.

[22] Guo Z, Wang Z, Weng X, Tang Y, Wu D, Cheng F, *et al*. The safety and efficacy of Sotn ureteroscopy for renal and upper ureteral calculi: a prospective multicenter randomized controlled trial. Minerva Urology and Nephrology. 2024; 76: 221–229.

[23] Zhang L, Fei X, Jiang Z, Song Y. Comparison of the Efficacy of Different Surgical Approaches for Complicated Impacted Proximal Ureteral Calculi Based on a New Scoring Standard: A Matched-Pair Analysis. Journal of Endourology. 2023; 37: 462–466.

[24] Wang J, Zhu X, Yao H, Tang W. Effectiveness of Enhanced Recovery After Surgery in the Perioperative Period for Patients with Ureteral Calculi. Alternative Therapies in Health and Medicine. 2023; 29: 354–359.