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Original Article

Clinical factors of stone free rates after percutaneous nephrolithotomy for staghorn calculi

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Abstract: Urinary stone is a worldwide disease and percutaneous nephrolithotomy (PCNL) is the most commonly used operation for staghorn calculi. Research indicated that SFR for staghorn calculi in one stage of PCNL showed 50%-91% results, under standard operation, standard instrument and professional treatment route. The present study aimed to explore the clinical factors of stone free rates (SFR) after PCNL for staghorn calculi. This retrospective study included 527 patients with staghorn calculi after one stage single channel PCNL. Associated factors with postoperative SFR after PCNL for staghorn calculi were analyzed using logistic regression model. The total SFR was 68.9% (363/527) in this group. 164 patients were diagnosed as residual stone after operation. In multivariate analysis suggested that factors of whether branched renal pelvis or not (OR=5.369, 95% CI: 0.957~30.109, *P*=0.056), Maximum stone diameter (OR=1.812, 95% CI: 1.088~3.016, *P*=0.022), minimum ratio of neck length to width renal transverse diameter (OR=0.002, 95% CI: 0~0.214, *P*=0.008), Average neck length (OR=5.842, 95% CI: 1.019~33.501, *P*=0.048). In conclusion, there are clinically significant factors of PCNL for staghorn calculi. Through logistic regression model, factors were correlated and preliminarily evaluated for the SFR after phase 1 operation, which intensely contributed to develop the individual medical programs.

Keywords: Staghorn calculi, percutaneous nephrolithotomy, stone free rates, urinary stones

Introduction

Urinary stone is a worldwide disease with approximately 5% new cases every year [1]. China is one of the areas with highest risk of urolithiasis, which incidence rate was high as 5-10% in the high case rate of 5-10% in the southland. In the last two decades the staghorn stones treatment has changed from open surgery to minimally invasive methods such as percutaneous nephrolithotomy (PCNL), ESWL, and combinations of PCNL and ESWL (extracorporeal shock wave lithotripsy). Percutaneous nephrolithotomy (PCNL) is the most commonly used operation for staghorn calculi [2], which is clinically common in case of complex renal calculi. Nowadays, the complete removal of staghorn calculi by PCNL is challenging for the surgeon. The main advantage of PCNL is avoiding the long lumbar incision of open surgery. Therefore patients who undergo PCNL benefit from decreased analgesic requirements, and shorter hospital stay and convalescence period.

Moreover, the stone-free rates after PCNL for staghorn stones were significantly higher than ESWL. However, PCNL for staghorn stones is a high skill-demanding surgical procedure. Mastering the techniques of percutaneous renal access, intracorporeal lithotripsy, and the use of rigid and flexible nephroscopic manipulations is essential for safe PCNL in this kind of stones. In addition, there can be a need for multiple percutaneous tracts or several sessions of PCNL to remove all stone branches, and secondary procedures such as ESWL might be required for residual fragments. The main concern about PCNL for staghorn stones was its potentially dangerous morbidity, e.g. haemorrhagic, sepsis and adjacent-organ injuries. These are the reasons for restricting the use of PCNL for treating staghorn stones to tertiary-care stone centres that have a high volume of cases, experienced endourologists, and all the instruments for stone management and treatment of complications [3].

Multi-stage and multi-channel operation combined treatments are necessary to remove the stone completely. However, multi-stage operation has more potential complications [4], such as haemorrhage, urinary extravasation, injury of adjacent organs.Combined treatment techniques like PCNL with flexible ureteroscopy were reported to improve the SFR, but need higher treatment cost. Under standard operation, standard instrument and professional treatment route, research reported that the SFR for staghorn calculi in one stage of PCNL was 50%-91% [5-8]. The key factors affecting SFR are the stone size, location, complexity, kidney structure, puncture channel and operative skilled [7-21]. The high stone-free rate of minimally invasive surgery has become the main attention in clinical fields [20, 21]. Our department has collected numerous PCNL cases of staghorn calculi from past 10 years. In the present study, the relationship between independent variables (i.e., patients and stone features) has been correlated with the dependent variable (i.e., SFR) for stable surgical procedure and establishing the predictive model.

Materials and methods

Patients

In this retrospective study, patients with staghorn calculi after one stage single channel PCNL at Zhejiang Provincial People's Hospital were included between January 2005 and January 2015. The patients meeting the below criteria were exclude: 1) The systemic hemorrhagic disease without correction; 2) Acute urinary tract infection or pyonephrosis without treatment; 3) Patients with severe heart disease and pulmonary incompetence who cannot undertake operation; 4) Uncontrolled diabetes and hypertension patients as well as tuberculosis patients; 5) Stone with large size that estimated cannot be cleared completely after numbers of PCNL; 6) Renal anatomic malformation with coexisting staghorn calculi; 9) Lordosis or scoliosis, obesity or patient who cannot tolerate the prone position. This study was approved by the ethics committee of the First Affiliated Hospital, Medical School of Zhejiang University.

Diagnostic criteria used in this study

1) Staghorn calculi-stone: Filled in pelvis or at least one kidney calyx [8]; 2) Bacteriuria: Urinary bacterial count ≥105/ml in the middle of urina sanguinis or clean urine culture was positive [9]; 3) Chronic renal insufficiency: Renal function incomplete compensation type, Scr ≥177 μmol/L, with or without toxuria [10]; 4) Coagulation disorders: Platelet count $<50\times10^9$/L or progressively decline; PT prolonged more than 3 s than control; APTT>35 s; TT>20 s or disseminated intravascular coagulation (DIC) [11]. 6) Hydronephrosis-mild hydronephrosis: Kidney shape and size are normal in ultrasound. Renal parenchyma thickness and echo are normal, separation of renal collection system is about 2 to 3 cm. 7) Hydronephrosis: The rim of minor renal calices is full, flatten or slightly stand out in X-ray but with fine excretion function. Moderate hydronephrosis: in ultrasound, renal volume mildly increased with full shape and thin parenchyma. Kidney column did not show clearly, while kidney pelvis and calices expanded clearly. Renal collection system is about 3 to 4 cm. In IVP, minor renal calices expanded to drumstick. Kidney pelvis is round and blunt, and ureter thickened above obstruction point, with developing delayed but fine kidney function. Severe hydronephrosis: in ultrasound, renal volumes largely increased to abnormal shape. Parenchyma attenuate cannot be observed. The whole kidney region was filled with opaque dark of fluid. Amongst these, there were linear echoes that separated renal column, radiating out in all the directions. Each dark area was connected with each other. The whole image is very similar to the butterfly, with renal collection system larger than 4 cm. In intravenous urography (IVU) examination renal contour increased, renal pelvis and calices expanded globularly or cystoid, renal cortex became thinner to different degree, renal pelvis and calices was not developed clearly or showed delayed development, glomerular filtration rate was severe damaged [12].

Surgical methods

Included cases were conducted by 3 experts (>100 cases of PCNL/person). The patients were placed in the lithotomy position under general anesthesia. Ureterscopy (8.0 F STORZ/OLYMPUS) was used to conduct retrograde ureter intubation. Changed to the prone position, a small pillow was put under the upper abdomen to make the back flat. Kidney area was bed hedgehopping. Saline was retrogradely dripped along the ureteral catheter to make artificial hydronephrosis. Ultrasonic positioning was conducted with Color Doppler ultrasound instrument (Denmark B-K 2202UV). Puncture point close to the target kidney beacon was chosen below twelfth rib or between tenth and

Table 1. Patient's characteristics

Variable	Mean ± SD	Range
Age (year)	50.33±13.88	14~84
Baric index (Kg/m^2)	23.57±3.65	13.8~44.1
Maximum stone diameter (cm)	2.90±1.34	2.0~15.7
Average stone CT value (HU)	704.59±182.90	280.37~1310.48
Average neck length (cm)	1.20±0.39	0.5~2.6
Minimum angle between macro axis of stone located calices and macro axis of ureter in renal pelvis (°)	55.49±34.44	28~157
Minimum ratio of neck length to width renal transverse diameter cm/cm	0.5389±0.1673	0.1875~1.375
Gender	Male	337 (63.4%)
	Female	190 (36.1%)
Stone position	Left side	248 (47.0%)
	Right side	229 (43.5%)
	Bilateral sides	50 (9.5%)
Whether branched renal pelvis	Yes	316 (60.0%)
	No	211 (40.0%)
Hydronephrosis	No	57 (10.8%)
	Mild	338 (64.1%)
	Moderate	132 (25.1%)
Bacteruria	No	379 (71.9%)
	Yes	148 (28.1%)
Bone density	Less	49 (9.3%)
	More	478 (90.7%)
Chronic renal insufficiency	No	380 (72.1%)
	Yes	147 (27.9%)
Disturbances of blood coagulation	No	469 (89.0%)
	Yes	58 (11.0%)

eleventh ribs from posterior line axillary to infrascapular line. Kidney needle (German, Urovision 18G) was used to puncture the kidney calices, where stylet was drawn out into zebra precursor or J-shaped guide wire. With their assistance, Fascial dilators (German, Urovision) expanded in turn to F20-22, leaving Urovision F20-22 Peel-awaysheath (German) were establish for renal passage. Standard nephroscopy (Wolf F20.8) was adopted to smash and clean stones with the fourth generation of ultrasonic combined pneumatic ballistic lithotripsy and pneumatic lithotripsy system. COOK or BARDF5-6 Double-J stent and Urovision F18-20 (German) was left to make renal fistula before the end. Plain abdominal radiograph or CT noncontrast enhanced scan was rechecked 3-7 days after operation. A complete removal of stone or the residue stone was less than 4 mm meant the success. If there were chuck or more residue stones, the second PCNL was conducted after 5-7 days (or combined with percutaneous nephrolithotomy under flexible ureteroscope). After 30-90 days the operation was conducted again based on the patients conditions. Total of 45 patients received more than two PCNL operations, while 76 patients received combined PCNL under flexible ureteroscopy and combined (ESWL).

Data collection and measurement

We collected the data of patients with staghorn calculi including age, BMI, Maximum stone diameter, Average stone CT value, Average neck length. And clinical data, laboratory examination, and imaging data like type-B ultrasonic, KUB, IVU and CT were collected. Then the independent variable index of patient data and stone feature were collected. Meanwhile, SFR after one phase operation was calculated. By scanning the three areas of the three maximum transverses of stone, we recorded the CT values of the core, the border and the middle part to get a mean CT value [13, 14]. Minimum angle between macro axis of stone located calices and macro axis of ureter in renal pelvis is the angle between axle wire of the lowest calices and the axle wire of pelvis ureter [15, 16]. Average neck length and the minimum ratio of neck length to width renal transverse diameter were calculated by intravenous urography and urinary system CT imaging. All the data were recorded by 2 observers after reaching a consensus.

Statistical methods

Statistical tests were carried out using SPSS Version 13.0 software (SPSS, Inc., Chicago, IL,

Table 2. Univariate analysis of SFR

Variable		Stone removal group	Residue stone group	Statistics	*P* value
Gender	Male	239 (70.9%)	98 (29.1%)	3.356	0.067
	Female	116 (61.1%)	74 (38.9%)		
Stone position	Left side	175 (70.6%)	73 (29.4%)	1.628	0.281
	Right side	157 (68.6%)	72 (31.4%)		
	Bilateral sides	32 (64.0%)	18 (36.0%)		
Hydronephrosis	No	35 (61.4%)	22 (38.6%)	1.406	0.160
	Mild	233 (68.9%)	105 (31.1%)		
	Moderate	93 (70.5%)	39 (29.5%)		
Whether branched renal pelvis	Yes	183 (57.9%)	133 (42.1%)	25.747	0.000*
	No	165 (78.2%)	46 (21.8%)		
Bacteruria	No	277 (73.1%)	102 (26.9%)	1.621	0.148
	Yes	97 (65.5%)	51 (34.5%)		
Chronic renal insufficiency	No	268 (70.5%)	112 (29.5%)	0.028	0.867
	Yes	96 (65.3%)	51 (34.7%)		
Disturbances of blood coagulation	No	326 (69.5%)	143 (30.5%)	0.053	0.818
	Yes	37 (63.8%)	21 (36.2%)		
Stone density	Higher than bone density	323 (67.6%)	155 (32.4%)	0.373	0.541
	Lower than bone density	37 (75.5%)	12 (24.5%)		
Age (year)		50.29±13.83	50.87±14.75	0.220	0.826
BMI (Kg/m^2)		23.56±3.69	23.69±3.10	0.191	0.849
Maximum stone diameter (cm)		1.72±0.93	4.11±2.81	4.646	<0.001
Average stone CT value (HU)		696.12±133.00	725.07±149.75	1.231	0.092
Average neck length (cm)		1.15±0.38	1.36±0.37	2.340	0.021
Minimum angle between macro axis of stone located calices and macro axis of ureter in renal pelvis (°)		57.12±34.81	50.61±33.57	0.783	0.436
Minimum ratio of neck length to width renal transverse diameter		0.5662±0.1608	0.4571±0.1631	2.808	0.006

BMI: body mass index, HU: hounsfield unit.

USA). SFR=P0 (/P0+P1) ×100%, P0 means the cases of no obvious stone or stone fragments <4 mm, P1 means the cases of stone existence. Quantitative data were expressed as means and standard deviations, and independent samples t-tests were used to detect significant differences. Qualitative data were expressed as frequencies and percentages and chi-square tests were used for comparison. The relationship between independent variables (patients and stone features) and SFR of one phase PCNL were established for logistic regression of univariate and multivariate model. After acquiring the statistically significant preoperative variable, ROC curve was drawn by ROCR statistical package and Logistic regression model was established to evaluate the SFR of one stage operation. Statistical significance was considered for $P<0.05$.

Results

Patients' characteristics

Total 527 patients were included in this study. The patients' mean age was 50.33±13.88, 337 (63.4%) were male. Baric index (Kg/m^2), maximum stone diameter (cm), average stone CT value (HU), average neck length (cm) were 23.57±3.65, 2.90±1.34, 704.59±182.90, 1.20±0.39 respectively. Other clinical data about patients characteristics including stone position [229 (43.5) right side, 50 (9.5) Bilateral side], hydronephrosis, bacteruria, bone density, chronic renal insufficiency, disturbances of blood coagulation were displayed in **Table 1**.

Perioperative data and stone free rates

The total SFR was 68.9% (363/527) in this group. 164 patients were diagnosed as residual stone after operation. The operating time was 73.2±11.4 min and hospitalization days were 12.1±3.5 d. After operation, Hgb decreased 18.2±4.6 g/L. Delayed hemorrhage occurred in 68 patients with bleeding amount of 200~700 mL. Among them, 42 cases were cured by expectant treatment and 26 cases were cured by super selective artery embolization under digital subtraction angiography (DSA). 16 cases had a fever (T>38.5°C) with 11 cases recovery by anti-infective therapy and 5

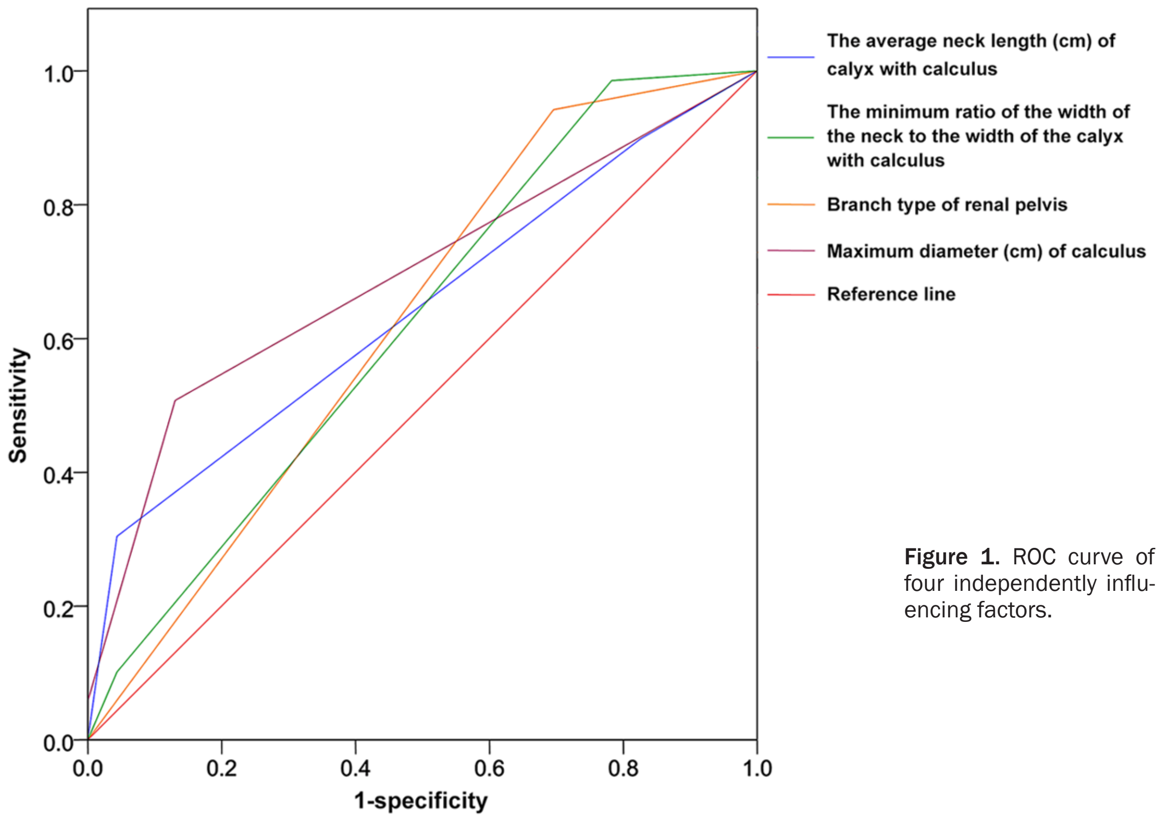

Figure 1. ROC curve of four independently influencing factors.

cases recovery by obstruction removal after two-stage operation. 6 cases suffered from mild pleural effusion and 4 cases had moderate pyoperitoneum, who were cured by expectant treatment. Neither surrounding organs nor collective systems needed second operation. Fistula was pulled out after 5-7 days post-operation. Double-J stent was pulled out after 1-3 months. 85 cases of residual stone received two-stage or multi-stage PCNL. 71 cases received flexible ureteroscope holmium laser lithotripsy operation (FURL). 8 cases of residual stone required ESWL and urinary calculus removal by medicine, with follow up for 3-6 months. Residual stone still existed in 14 patients of two-stage or multi-stage PCNL and 3 cases of urinary calculus removal by medicine.

Univariate and multivariate analysis

Univariate analysis suggested that factors of whether branched renal pelvis, maximum stone diameter, average neck length, minimum ratio of neck length to width renal transverse diameter were associated with Stone free rates (**Table 2**).

Figure 1 display the ROC curve of four independently influencing factors. In multivariate analysis suggested that factors of whether branched renal pelvis or not (OR=5.369, 95% CI: 0.957~30.109, P=0.050), Maximum stone diameter (OR=1.812, 95% CI: 1.088~3.016, P=0.022), minimum ratio of neck length to width renal transverse diameter (OR=0.002, 95% CI: 0~0.214, P=0.008), Average neck length (OR=5.842, 95% CI: 1.019~33.501, P=0.048). Based on above factors, we esta=-blished the corresponding Logistic regression model: $P=a+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4$. Among them, P represented SFR; a was constant term (-2.135; β_j(j=1, 2, 3, 4) was partial regression coefficient; X was independent variable; X_1 represented whether branched renal pelvis or not, X_2 was maximum stone diameter, X_3 was average neck length and X_4 was the minimum ratio of neck length to width renal transverse. Based on this equation, we predicted the SFR before operation. The higher the p value, the higher the successful rate (**Table 3**).

Discussions

Urinary stone is a worldwide disease. China is one of the three highest risk areas of urolithiasis. Only PCNL is the most commonly used method for staghorn calculi. Even the complete

Table 3. Logistic regression analysis of SFR

	Coefficient	OR	95% CI	*P* value
Whether branched renal pelvis	1.681	5.369	0.957~30.109	0.050
Maximum stone diameter	0.594	1.812	1.088~3.016	0.022
Minimum ratio of neck length to width renal transverse diameter (cm/cm)	-5.996	0.002	0~0.214	0.008
Average neck length	1.765	5.842	1.019~33.501	0.048

removal of staghorn calculi by PCNL is challenging for the urologist. Since the introduction of PCNL for treating renal stones there have been marked improvements in the techniques and instruments that have resulted in using PCNL for treating complex and staghorn stones. Currently it has become the first choice for patients with large, complex and staghorn renal stones. The goal of treatment of a staghorn stone is complete stone clearance with minimal morbidity. Multi-stage and multi-channel operation combined treatments are necessary to remove the stone effectively. However, due to many complications of multi-stage operation, it was avoided. The high stone-free rate of minimally invasive surgery has becoming the attention in clinical fields. Urinary stone minimally invasive treatment center has collected numerous PCNL cases of staghorn calculi from past 10 years. This study was conducted to establish the relationship between independent variables (i.e., patients and stone features) with the dependent variable (i.e., SFR) along with stable surgical procedure for establishing the predictive level [3].

The tools employed for evaluation include clinical data, laboratory examination, type-B ultrasonic KUB, IVU and CT and stone features were considered as independent variables, while factors like sexuality, age, BMI, hydronephrosis degree, bacteruria or not, azotemia or not, coagulation disorders or not, branched renal pelvis or not, stone numbers, stone location, maximum stone diameter, stone density, mean CT-number were not considered for the purpose. Minimum angle between max axis of stone located calices and max axis of ureter in renal pelvis, average neck length, and minimum ratio of neck length to width renal transverse diameter were also taken into consideration during study. Meanwhile, the dependent variable like SFR of one-stage operation was considered for conduct univariate analysis, bipartite regression analysis, and ROC curve analysis to establish Logistic regression model for SFR evaluation. In the calculus research, the relationship between successful rate of ESWL, URS and PCNL and stone features such as BMI, hydronephrosis, stone location, numbers, density (CT value) and size has been reported as much as possible [15-18]. In the light of literature reports, the most widely range of preoperative features to conduct analysis were collected and introduces originally some valuable characteristics such as whether branched renal pelvis or not, average neck length and minimum ratio of neck length to width renal transverse. The results were accordance with previous reports with SFR for PCNL of staghorn calculi [15-18].

The Logistic regression formula, nomogram or scores system were used to establish the prediction model, which was constituted by preoperative factors. Ioannis Vakalopoulos predicted the curative effect of ESWL by mathematical model [19]. It indicated that sex, age, BMI, stone size, volume, density and multiple and diameter of connection between renal pelvis and ureter were influencing the independent variables. Meanwhile, a multivariant Logistics regression model with average SFR was 80%: P=1/1+e (-z). In the equation, 'e' represented napierian base) and 'z' equaled 'ct' added the value of each variable. We found that this model could improve the SFR. Wilson et al. established a practical evaluation system of stone score, which predicted the effect of URS by axial calculation of tomoscan and description of stone features (including stone size, location, block, numbers and CT value). When the score was lower than 9, the SFR was higher than 90% and one point decrease meant 10% decrease of successful rate. The Clinical Research Office of the Endourological Society (CROES) collected information of 5803 PCNL cases from 96 hospitals in worldwide. Models were set by the relationship between preoperative variables of stone and SFR. The variables included preoperative treatment, BMI, staghorn stone, chronic renal disorder and stone burden, location and numbers. The model was validated by bootstrap. The adjusted chi-square was used to rank predicted value of each variable. Nomograph was developed by key factors in the model, which aimed to predict the successful rate of PCNL by variable transformation [21]. Staghorn stone was complex and hard to remove, which usually had residual stone after the operation and easy to recurrent. In last decade, our minimal-invasive center for stone treatment conducted hundreds cases of PCNL. We had standard operation route and abundant experience, with one-stage SFR of 60-90%. We strictly screened the clinical data of PCNL who met the inclusion criteria. Our purpose was to develop a simple method to predict the SFR for PCNL. We evaluated the possibility and inevitability of four independently influential factors. We noted that the stone maximum diameter, the accumulated maximum diameter, stone superficial area and volume could represent the total load [22]. Our research also suggested stone maximum diameter had positive correlation with SFR. Branched renal pelvis, or represented an anatomical type in which pelvis was located in the renal sinus intrarenal pelvis. Branched renal pelvis has several features such as small volume of renal pelvis, long and narrow calices and easy to form upper urinary calculi, especially complex calculi. Traditional open surgery needed renal sinus pelvis lithotomy or united renal parenchyma lithotomy, which were difficult to conduct. This kind of anatomical structure of renal collecting system made it hard for nephrolithotomy to go through pelvis to each calix for stone exploration. Swing amplitude of nephrolithotomy body was greatly restricted, which effected the stone removal in each calix. Neck length and the ratio of the neck width and diameter were also the reason for the restriction of PCNL swing amplitude. The smaller ratio meant the larger region of blind area.

The above four factors as well as the follow-up of residual stone can help us do the measurement based on clinical data and preoperative imaging data (CT or IVP). Clinical data was easy to collect and then the data was put into the Logistic regression model for evaluation and quantifying probability value for predicting the SFR of PCNL for staghorn calculi. By this model, more prior notification could be told to patients to improve the treatment effect by adopting the best surgical methods, improving the surgical procedures or combining other surgical methods.

We also noted that the limitations of our research as follows that we didn't collect the full history of patients which neglected the influence of past surgical treatment on kidney anatomy and difficulty degree of stone removal. We also didn't have the data of stone constituent, which also had effect on the curative effect, especially for the residue and remove of break stones. Our following work aimed to expand the variables and the accumulation of samples to do more prospective study, which could verify the prediction of Logistic regression and the goodness of fit of practical SFR of PCNL.

In conclusion, our research applied Logistic regression analysis to establish the model of four independently influencing factors of SFR in PCNL for staghorn calculi. These factors maybe have excellent clinical significance for indications selection, surgery rationalization and standardization of PCNL for staghorn calculi.

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Disclosure of conflict of interest

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References

[1] Turney BW, Reynard JM, Noble JG and Keoghane SR. Trends in urological stone disease. BJU Int 2012; 109: 1082-1087.

[2] Guidelines on urolithiasis [EB/OL]. European Association of Urology (EAU) Guidelines. http://www.uroweb.org/guidelines/onlineguidelines. 2011.

[3] El-Nahas AR, Eraky I, Shokeir AA, Shoma AM, El-Assmy AM, El-Tabey NA, El-Kappany HA and El-Kenawy MR. Percutaneous nephrolithotomy

for treating staghorn stones: 10 years of experience of a tertiary-care centre. Arab J Urol 2012; 10: 324-329.

[4] Anand A, Kumar R, Dogra PN, Seth A and Gupta NP. Safety and efficacy of a superior caliceal puncture in pediatric percutaneous nephrolithotomy. J Endourol 2010; 24: 1725-1728.

[5] Scoffone CM, Cracco CM, Poggio M and Scarpa RM. Endoscopic combined intrarenal surgery for high burden renal stones. Arch Ital Urol Androl 2010; 82: 41-42.

[6] Preminger GM, Assimos DG, Lingeman JE, Nakada SY, Pearle MS, Wolf JS Jr; AUA Nephrolithiasis Guideline Panel. Chapter 1: AUA guideline on management of staghorn calculi: diagnosis and treatment recommendations. J Urol 2005; 173: 1991-2000.

[7] Perlmutter AE, Talug C, Tarry WF, Zaslau S, Mohseni H and Kandzari SJ. Impact of stone location on success rates of endoscopic lithotripsy for nephrolithiasis. Urology 2008; 71: 214-217.

[8] Kandasami SV, Rao RK, Arul M, Ranganath MS and Prasad TK. Synchronous twin track percutaneous nephrolithotomy: A preliminary experience. Indian J Urol 2008; 24: 118-119.

[9] Ye RG and Lu ZY. The fifth piece: urinary system disease. The seventh chapter: urinary tract infection. In: Internal medicine. 6th edition. Beijing: People's Medical Publishing House; 2001. pp. 529-529.

[10] Vanbelleghem H, Vanholder R, Levin NW, Becker G, Craig JC, Ito S, Lau J, Locatelli F, Zoccali C, Solez K, Hales M, Lameire N and Eknoyan G. The Kidney Disease: improving Global Outcomes website: comparison of guidelines as a tool for harmonization. Kidney Int 2007; 71: 1054-1061.

[11] Fang ZH, Ma YH, Wang J and Lian ZQ. Prothrombin time international normalized clinical application. Chinese Journal of Blood Transfusion 2000; 13: 105-107.

[12] Bai M and Zhang XL. Medical Radiology. 3rd edition. Beijing: People's Health Press; 2010. pp. 372.

[13] Nakada SY, Hoff DG, Attai S, Heisey D, Blankenbaker D and Pozniak M. Determination of stone composition by noncontrast spiral computed tomography in the clinical setting. Urology 2000; 55: 816-819.

[14] Williams JC Jr, Kim SC, Zarse CA, McAteer JA and Lingeman JE. Progress in the use of helical CT for imaging urinary calculi. J Endourol 2004; 18: 937-941.

[15] Resorlu B, Oguz U, Resorlu EB, Oztuna D and Unsal A. The impact of pelvicaliceal anatomy on the success of retrograde intrarenal surgery in patients with lower pole renal stones. Urology 2012; 79: 61-66.

[16] Ye LH, Li YL, Li WJ, Chen YL, Tao SX, Jiang XQ and Lou JX. Impact of lower calyceal anatomic structure on flexible fibreoptic ureteroscopy with Holmium laserin treatment of calyceal calculi. Chinese Journal of Urology 2013; 34 24-27.

[17] Bagrodia A, Gupta A, Raman JD, Bensalah K, Pearle MS and Lotan Y. Predictors of cost and clinical outcomes of percutaneous nephrostolithotomy. J Urol 2009; 182: 586-590.

[18] Coz F, Orvieto M, Bustos M, Lyng R, Stein C, Hinrichs A and San Francisco I. Extracorporeal shockwave lithotripsy of 2000 urinary calculi with the modulith SL-20: success and failure according to size and location of stones. J Endourol 2000; 14: 239-246.

[19] Vakalopoulos I. Development of a mathematical model to predict extracorporeal shockwave lithotripsy outcome. J Endourol 2009; 23: 891-897.

[20] Molina WR, Kim FJ, Spendlove J, Pompeo AS, Sillau S and Sehrt DE. The S.T.O.N.E. Score: a new assessment tool to predict stone free rates in ureteroscopy from pre-operative radiological features. Int Braz J Urol 2014; 40: 23-29.

[21] Smith A, Averch TD, Shahrour K, Opondo D, Daels FP, Labate G, Turna B, de la Rosette JJ; Croes Pcnl Study Group. A nephrolithometric nomogram to predict treatment success of percutaneous nephrolithotomy. J Urol 2013; 190: 149-156.

[22] Ito H, Kawahara T, Terao H, Ogawa T, Yao M, Kubota Y and Matsuzaki J. The most reliable preoperative assessment of renal stone burden as a predictor of stone-free status after flexible ureteroscopy with holmium laser lithotripsy: a single-center experience. Urology 2012; 80: 524-528.