

Characteristics of patients with fluid extravasation during retrograde ureteroscopic holmium laser lithotripsy for renal calculi

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ABSTRACT

الأهداف: التحقق من عوامل الخطر المرتبطة بتسرب السوائل أثناء إجراء عملية تفتيت الحصى بواسطة التنظير الرجعي واستخدام تقنية ليزر هولميوم للمرضى المصابين بحصى الكلى.

الطريقة: لقد قمنا بمراجعة السجلات الخاصة بالمرضى الذين خضعوا لعملية تفتيت الحصى (الحجم: 10 إلى 20 مم) بواسطة التنظير الرجعي واستخدام تقنية ليزر هولميوم في مستشفى رينمين التابع لجامعة ووهان، ووهان، الصين وذلك خلال الفترة من يناير 2004م إلى ديسمبر 2010م. لقد قمنا بمراجعة السجلات السريرية الخاصة بحوالي 327 مريض، بالإضافة إلى تحديد العلاقة بين العوامل السريرية المختلفة وتسرب السوائل أثناء إجراء العملية. شملت العوامل السريرية المتعلقة بالمرضى كلاً من: الجنس، والعمر، ودرجة تموه الكلى، وإجراء عمليات سابقة لإخراج الحصى، والتهاب القناة العلوية البولية، ووضع غمد في مجرى الحالب، ومدة إجراء العملية. لقد قمنا باستخدام برنامج التحليل الإحصائي (SPSS 16)، واختبار χ^2 ، والانحدار اللوجستي الثنائي من أجل تحليل البيانات ومقارنتها.

النتائج: لقد ظهرت مضاعفات تسرب السوائل أثناء إجراء العملية الجراحية لدى 35 مريض. كما أشارت نتائج الدراسة إلى عدم وجود علاقة بين عوامل العمر، والجنس، ودرجة تموه الكلى من جهة وحدوث هذه المضاعفات من جهة أخرى. وبالمقابل فقد كانت العوامل التالية مسؤولة عن حدوث تسرب السوائل وهي: إجراء عمليات سابقة لإخراج الحصى من غير وضع غمد في مجرى الحالب، والتهاب القناة العلوية البولية، وطول مدة إجراء العملية.

خاتمة: أظهرت هذه الدراسة بأن الاختيار المناسب للمرضى، والتحكم بالتهاب القناة العلوية البولية، ووضع غمد في مجرى الحالب بشكل روتيني، والتحكم بفترة إجراء عملية التنظير قد يساعد في تقليص مضاعفات تسرب السوائل أثناء إجراء عملية تفتيت الحصى بواسطة التنظير الرجعي واستخدام تقنية ليزر هولميوم للمرضى المصابين بحصى الكلى.

Objectives: To explore the risk factors of fluid extravasation during retrograde ureteroscopic holmium laser lithotripsy for renal calculi.

Methods: Three hundred and twenty-seven patients with renal calculi ranging 10 to 20 mm received retrograde ureteroscopic holmium laser lithotripsy at Renmin Hospital of Wuhan University, Wuhan, China from January 2004 to December 2010. The clinical records were reviewed, and the correlation was studied between various clinical factors and fluid extravasation complications during operation. The clinical factors to be tested included patients' gender and age (<30, 30-50, and >50 years), hydronephrosis degree, previous intervention for renal calculi (none, shock-wave lithotripsy, and open surgery), upper urinary tract infection, ureteral access sheath placement, and procedure duration (<60, 60-120, and >120 mins). The data were processed by SPSS Version 16.0 statistical software, χ^2 test, and binary logistic regression were used for analysis.

Results: Fluid extravasation complications appeared in 35 patients. Patients' gender, age, and hydronephrosis degree were irrelevant to the occurrence of fluid extravasation, while having previous open surgery for renal calculi, without ureteral access sheath placement, upper urinary tract infection, and long procedure duration were all responsible for higher incidence of the complications.

Conclusion: Reasonable selection of patients, effective control of upper urinary tract infection, routine ureteral access sheath placement, and controlling procedure duration help to decrease the incidence of fluid extravasation complications in retrograde ureteroscopic holmium laser lithotripsy for renal calculi.

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At present, extracorporeal shock-wave lithotripsy (SWL) is the standard treatment for renal calculi 20 mm or less. Retrograde ureteroscopic lithotripsy (URL) procedures may be used as alternatives or remedies for some SWL-resistant calculi.¹⁻⁴ An advantage of URL is that it allows visual verification of the calculi and enables the removal of fragments. For calculi ranging between 10-20 mm, URL has been associated with significantly higher overall stone-free rates than those achieved with SWL so that for these patients URL should be considered primary therapy.¹ However, continuous normal saline irrigation during URL procedure, which is obligatory to ensure the smooth entry of the ureteroscope as well as the clarity of operating field, will inevitably result in elevated renal pelvic pressure (PP). High PP brings systemic absorption of irrigation fluid into perirenal tissue or blood circulation, and in these cases, complications, such as fluid extravasation, can occur.⁵ The aim of this retrospective study was to explore the risk factors of fluid extravasation during URL for renal calculi.

Methods. Three hundred and twenty-seven patients with renal calculi ranging between 10-20 mm (172 men and 155 women, mean age 48 years, range 21-77) were recruited for retrograde URL by one operation team at Renmin Hospital of Wuhan University, Wuhan, Hubei, China, between January 2004 and December 2010. All patients gave written informed consent to operation before procedures. The study was approved by the Ethical Committee of Renmin Hospital of Wuhan University and was carried out according to the principles of the Helsinki Declaration.

One hundred and fifty-two patients had one renal calculus and others had 2 or more. Fifty-eight patients had combined ureteral and renal calculi, and others had only renal calculi, including 145 patients with calyceal calculi, 73 with pelvic calculi, and 51 with concomitant calyceal and pelvic calculi. There were 678 treated calculi (mean 2.07, range 1-4 per patient). The size of the maximum renal calculi for each patient ranged from 12-20 mm (mean 17 mm); the total calculi area for each patient ranged from 168-760 mm² (mean 433 mm²). One hundred and twenty-six patients had received 2-3 SWL procedures, and 105 had previous open surgery for renal calculi, while the rest had never received any interventions. Ureteral access sheath was placed in 196 patients, but not in 131 patients during operation. Ultrasonography, kidneys, ureters and

bladder (KUB) plain film and intravenous urography (IVU) were routinely conducted preoperatively to confirm the diagnosis, and in selected cases, retrograde ureteropyelography and CT scan were performed. Routine urine test was adopted to determine whether a patient had urinary tract infection when hospitalized, or prior to procedure if necessary. Patients who had previous renal extravasation or obvious perforation in the ureter, pelvis, or calyx during procedures were excluded from the study. Those who had critical stricture or twist of the ureter, which hindered the entry of ureteroscopes, were also excluded.

Bacteriuric patients were treated for 3 days to control urinary tract infection prior to the procedure with oral antibiotics guided by sensitivities. Procedures were performed under continuous epidural anesthesia or general anesthesia. All patients were treated with a 6.9F flexible ureteroscope. A 200 μm holmium YAG laser and flexible triradiate graspers were used for calculi fragmentation and retrieval of fragments. The saline irrigation pressure and flow were set according to the certain situation during procedures, which was the minimum to ensure a smooth entry of the ureteroscope and clear operative field. Calyceal neck stenosis in 10 patients, relative stenosis in UPJ (ureteropelvic junction) in 8, ureter stricture in 5, and ureteral polyps in 4 were treated with holmium laser ablation and vaporization during procedures. 5F-6F double J tubes were routinely kept in the ureter underwent operation for 3-4 weeks postoperatively. Repeat URL and SWL were considered as auxiliary treatment alternatives when indicated.

The procedure was considered successful if all the calculi were extracted or if the resulted fragments were smaller than 3 mm, small enough not to be considered as obstructive.⁴ The follow-up protocol included abdominal ultrasonography, KUB plain film (in patients with radio-opaque calculi), and in selected cases, IVU. Color Doppler ultrasonography were conducted by one radiologist to check whether large retained calculus or renal extravasation existed at the end of procedure, and when a patient under continuous epidural anesthesia vomited or complained of intraoperative lumbar or abdominal pain (sign of fluid extravasation), intraoperative ultrasonography was undertaken immediately. Regular test and electrolytes of blood were monitored at the end of procedures conventionally, or during operation when a patient was suspected of suffering from excessive fluid absorption due to renal extravasation, and central venous pressure (CVP) was also monitored in serious cases when indicated. The occurrence of renal subcapsular, perirenal or peritoneal effusion, and water intoxication were all identified as fluid extravasation complications.

The data were processed by SPSS version 16.0 statistical software. The relationship between the

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occurrence of fluid extravasation complications and various clinical factors was analyzed by χ^2 test and the underlying factors above were further analyzed by binary logistic regression. The clinical factors to be tested included: patients' gender and age, previous intervention for renal calculi, hydronephrosis degree, upper urinary tract infection, ureteral sheath placement and procedure duration. A $p < 0.05$ was considered statistically significant and confidence level was set at 95%.

Results. The mean procedure duration was 98 minutes (range 40-185). The overall success rate was 86.2% (282/327). Forty-five cases failed for various reasons. Five failures resulted from an inability to find lower calyceal calculi during procedures, and 8 failures were due to the reduction of the flexibility of the fibered ureteroscope after insertion of holmium laser fiber, which resulted in lower calyceal calculi invisible. Some lower calyceal calculi were visible with use of flexible ureteroscope, however, the flexibility of the ureteroscope was reduced with the insertion of a laser fiber into its working lumen, resulting in invisible of lower calyceal calculi mentioned above. Resulting larger fragments (>3 mm) accounted for 18 failures. The remaining 14 failures were caused by the discontinuance of procedures: 3 ceased due to water intoxication, 5 ceased for patients' complaint of lumbar or abdominal pain, and the other 6 ceased for blurred operating field due to hemorrhage. Accordingly, one session of repeat URL was conducted for 13 patients, and 1 to 2 SWL for the remainder.

Fluid extravasation complications occurred in 35 patients in this study, including: 16 cases of renal subcapsular effusion, 14 cases of perirenal effusion, and 5 cases of concomitant perirenal and peritoneal effusion. Three cases of intraoperative and 2 cases of postoperative water intoxication were presented in the latter 5 cases. The representation of water intoxication included an obvious drop in hemoglobin and serum level of calcium and phosphorus compared to preoperative records and a

rise in CVP. All 35 cases had a postoperative fever (body temperature at 38-39° in 16 cases and above 39° in 19 cases) among which 7 cases of perirenal abscess and 5 cases of septic shock occurred postoperatively. Effective measurements, including puncture ostomy drainage, improving colloid osmotic pressure, diuretic therapy, cardiac treatment, correcting electrolyte imbalance, and strengthening of anti-infective and supportive measures, were taken. All patients recovered within 5-14 days postoperatively. No other serious complications were observed in this study. Tables 1 & 2 list the incidence of

Table 1 - Comparison of patients with and without fluid extravasation complications in terms of factors related to the patient and procedure by χ^2 test (N=327).

Variables	Fluid extravasation (+) n=35	Fluid extravasation (-) n=292	Incidence (%)	P-value
<i>Gender</i>				0.388
Women	19	136	12.3	
Men	16	156	9.3	
<i>Age (years)</i>				0.114
<30	5	78	6.0	
30-50	13	119	9.8	
>50	17	95	15.2	
<i>Previous intervention</i>				0.003
None	6	90	6.3	
SWL	9	117	7.1	
Open surgery	20	85	19.0	
<i>Hydronephrosis</i>				0.520
Grade 0	3	45	6.3	
Grade 1	8	77	9.4	
Grade 2	12	81	12.9	
Grade 3	12	76	13.6	
<i>Upper urinary tract infection</i>				0.007
Yes	18	85	17.5	
No	17	207	7.6	
<i>Ureteral sheath placement</i>				0.004
Yes	13	183	6.6	
No	22	109	16.8	
<i>Procedure duration (min)</i>				0.001
<60	3	105	2.8	
60-120	11	89	11.0	
>120	21	98	17.6	

SWL - extracorporeal shock-wave lithotripsy

Table 2 - The relationship analyzed by binary logistic regression between the incidence of fluid extravasation and previous intervention, upper urinary tract infection, ureteral access sheath placement, and procedure duration.

Incidence	B	SE	Wald	df	P-value	OR	95% CI for OR
Previous intervention*	None	None	25.961	2	0.000	None	None
Previous intervention (1) ^a	1.044	0.569	3.370	1	0.066	2.840	0.932-8.657
Previous intervention (2) ^b	1.552	0.460	11.377	1	0.001	4.720	1.936-11.630
Upper urinary tract infection*	0.963	0.383	6.337	1	0.012	2.619	1.238-5.544
Ureteral access sheath placement*	-1.028	0.415	6.147	1	0.013	0.358	0.159-0.806
Procedure duration*	None	None	20.645	2	0.000	None	None
Procedure duration (1) ^c	1.285	0.715	3.228	1	0.072	3.614	0.890-14.675
Procedure duration (2) ^d	1.340	0.475	7.937	1	0.005	3.818	1.503-9.694
Constant	3.431	0.946	13.162	1	0.000	30.913	None

*Contrast model: repeated. ^anone versus SWL, ^bSWL versus open surgery. ^cless than 60 minutes versus 60-120 minutes, ^d60-120 minutes versus >120 minutes. SWL - extracorporeal shock-wave lithotripsy. 1 and 2 - produced by binary logistic regression.

CI - confidence interval, OR - odds ratio, df - degree of freedom

fluid extravasation complications in relation to various clinical factors.

Discussion. For all SWL-resistant calculi, other methods of fragmentation are needed. Although it has very good results (90% stone-free rate), percutaneous nephrolithotomy (PCNL) is a method with a high morbidity rate.⁶ The development of flexible ureteroscopes, thin and flexible holmium laser fibers have made it possible to reach and fragment calculi in all parts of the kidney during URL. The holmium laser not only fragments calculi, but also vaporizes and pulverizes calculi to a 'dust' that can be passed spontaneously. Besides this merit, the capability to deal with some concurrent pathological conditions, such as stenosis in the calyceal neck or UPJ, and polyps, or stricture in the ureter is an obvious advantage of the ureteroscopic procedure over SWL. Compared with PCNL, the retrograde ureteroscopic procedure is maneuvered through natural access and thus is less invasive. However, increased PP induced by irrigation during ureteroscopic procedures might cause renal extravasation or even rupture of the collecting system.⁵ Pelvic pressure is physiologically lower than 10 cm H₂O⁷ and intrarenal reflux occurs when it exceeds 40 cm H₂O.⁸ Studies have shown that mean PP markedly increased and peaked higher than 300 mm Hg (408 cm H₂O) during ureteroscopic lithotripsy with saline irrigation.^{9,10} When intrarenal reflux happens, the primary site of extravasation is the sinus. From the sinus, backflow may extend toward the hilum; hence, into the retroperitoneal space as well as into the veins and lymphatics.⁵

As PP during the procedure was directly affected by irrigation pressure, the latter was minimized according to the demands of the procedure to diminish its effect on fluid extravasation in our study. However, PP is also likely to be regulated by some other factors, including elasticity of the kidney, intraoperative drainage in the upper urinary tract, and procedure duration. In theory, the elasticity of the kidney may be related to patients' characteristics such as gender, age, hydronephrosis degree and previous intervention for renal calculi. Besides the actual PP, the threshold PP for backflow is also vital to fluid extravasation, which is probably influenced by pathological conditions such as infection in the upper urinary tract. Therefore, the relevance between the factors mentioned above and incidence of fluid extravasation complications was analyzed in this study. Analysis in effects of individual factors on fluid extravasation showed that, except for patients' gender, age and hydronephrosis degree, another 4 factors (previous intervention, urinary tract infection, placing ureteral access sheath, or not and procedure duration) were related to the incidence of fluid extravasation

complications. The results above were further confirmed by binary logistic regression analysis, which was adopted to eliminate the confounder of the cross-effects existing among various factors. Open surgery might destroy the original anatomy of the kidney and induce a decrease of its elasticity to some extent (for example, by scar formation), leading to higher PP under the same perfusion pressures. Thereby, patients with open surgery history accounted for the higher incidence of fluid extravasation complications in this study. This result indicated that previous open surgery for renal calculi was a contributing factor of fluid extravasation during URL.

In the case of upper urinary tract infection, the threshold PP for fluid extravasation might be decreased markedly, which resulted from the increased permeability due to the edema or even desquamation of renal pelvic and calyceal mucosa. Consequently, in this study, the incidence of fluid extravasation complications in patients with upper urinary tract infection was significantly higher than those without infection. Postoperative fever >38° occurred in all of 35 patients with fluid extravasation complications, which might be related to the backflow of a variety of pyrogen in urine, such as bacteria, broken stone particles, and tiny blood clots. Backflow of bacteria and infective particles can also lead to the spreading of infection, from which 7 cases of perirenal abscess, and 5 cases of septic shock resulted in the current study. Percutaneous nephrostomy would be a good choice in serious cases to help control upper urinary tract infection before operation. In addition to the above 2 factors, our results showed that the placing ureteral access sheath or not, and the length of procedure duration affected the incidence of fluid extravasation complications as well.

Due to the expensive cost of ureteral access sheath and our worry regarding the potential long-term ureteral stricture formation caused by its use,¹¹ the sheath was not routinely placed during URL in the beginning of our series, which led to a higher incidence of fluid extravasation complications. When this was perceived afterwards, the regular use of the sheath significantly reduced the incidence of these complications. Auge et al¹² showed that the mean PP during ureteroscopic procedure was significantly reduced with the use of ureteral access sheath. Drainage through ureteral access sheath is perhaps not enough to control PP within physiological range during procedures; nevertheless, by draining out part of the high-pressure fluid in the collecting system, it might reduce PP, and eventually, fluid extravasation to a greater extent. No ureteral stricture formation was observed in patients using the access sheath on follow-up. The results above and others,¹¹ indicate the safety of ureteral sheath use in URL, and its value in decreasing fluid extravasation.

From the current study, a significant difference could be seen in fluid extravasation among the 3 groups according to procedure duration. Specifically, the incidence in patients with procedure duration 120 min or longer was markedly higher than those with duration shorter than 120 min, while no statistical difference existed between patients with procedure duration of 60-120 min, and shorter than 60 min. Generally, the procedure duration depends on the calculi mass and concentration (stone burden) and operating skill. The bigger mass and the higher concentration of the calculi, the more time for fragmentation, more skilled the operator, higher efficiency of the procedure.

There are some limitations in this study, including its retrospective characteristic, a relatively small sample, and insufficiency in patient selection. The chance of fluid extravasation was elevated in patients with other pathology such as UPJ stenosis compared with those without, due to its treatment aggravating urinary damage. In addition, stone burden, and the operator's skill are 2 main potential factors affecting fluid extravasation. Due to the difficulty in quantification, these 2 factors were not studied individually here. As both them affected procedure duration, the influence of procedure duration on extravasation was included in the analysis. Further prospective research, with a larger sample, and strict inclusion criteria for patients should be carried out to validate the findings of this study.

In conclusion, this study shows that previous open surgery for renal calculi, upper urinary tract infection, without ureteral access sheath placement, and long procedure duration were all responsible for fluid extravasation complications in ureteroscopic lithotripsy for renal calculi. Accordingly, reasonable selection of patients, effective control of upper urinary tract infection, routine ureteral access sheath placement, and controlling procedure duration helps to decrease the incidence of fluid extravasation complications in

retrograde ureteroscopic holmium laser lithotripsy for renal calculi.

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