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Original Article

Predictive Factors for Ureteral Double-J-Stent-Related Symptoms: A Prospective, Multivariate Analysis

*Chen-Hsun Ho,[1,3] Huai-Ching Tai,[1] Hong-Chiang Chang,[1] Fu-Chang Hu,[2] Shyh-Chyan Chen,[1] Yuan-Ju Lee,[1] Jun Chen,[1] Kuo-How Huang[1]**

Background/Purpose: Whether the length of stent affects stent-related symptoms after urological procedures remains controversial. We aimed to evaluate the predictive factors for stent-related urinary tract symptoms after uncomplicated ureteroscopic lithotripsy (URSL).

Methods: We prospectively recruited a total of 59 patients who underwent URSL and 6-Fr double-J ureteral stent placement. The demographic and perioperative data and stent characteristics, including the length (22, 24 or 26 cm), position of proximal end (upper calyx or pelvis), position of distal end (crossing midline or not), and configurations of both ends (complete or incomplete curl) were recorded. All patients completed a self-administered questionnaire to evaluate the stent-related urinary symptoms, bladder pain, flank pain and hematuria 1 week after the procedure. All variables were analyzed by a proportional odds logistic regression model.

Results: Twenty-two male (37.3%) and 37 (62.7%) female patients were enrolled in this study. Their mean age was 53.7 ± 12.9 years. The mean body height was 161.9 ± 7.9 cm (range, 145.9–178 cm). In multivariate analysis, the 26-cm stent was independently associated with the severity of frequency, urgency, and nocturia symptoms. Crossing the midline of the distal end was significantly associated with urge incontinence. The 24-cm and 26-cm stents were both very strongly associated with the severity of hematuria. Crossing the midline of the distal end was significantly associated with bladder pain.

Conclusion: The length of stent and crossing the midline of the distal end were significantly associated with stent-related symptoms after URSL. Selection of the proper length of double-J stent is the most important factor in minimizing stent-related symptoms.

Key Words: stent-related symptoms, ureteral stent, ureteroscopic lithotripsy

Endourological procedures are commonly performed worldwide. The double-J ureteral stent is widely used to relieve or prevent ureteral obstruction after these procedures. Although insertion of a ureteral stent maintains ureteral patency and ensures drainage, some patients encounter some discomfort such as irritative bladder symptoms, hematuria, bladder pain, and flank pain; all of

[1]Department of Urology, National Taiwan University Hospital and National Taiwan University College of Medicine, and [2]National Center of Excellence for General Clinical Trial and Research, National Taiwan University Hospital, and [3]Division of Urology, Department of Surgery, Buddhist Tzu Chi General Hospital, Taipei Branch, Taipei, Taiwan.

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***Correspondence to:** Dr Kuo-How Huang, Department of Urology, National Taiwan University Hospital, 7 Chung-Shan South Road, Zhongzheng District, Taipei 100 Taiwan.
E-mail: khhuang123@ntu.edu.tw

which have a negative impact on the quality of life.[1–3] The most common complaints after ureteroscopic stone lithotripsy (URSL) are associated with stents left in place postoperatively. The exact pathophysiology of stent-related symptoms remains unknown. Bladder symptoms are thought to be a result of mucosal irritation of the nerve located in the submucosa in the bladder trigone. Flank pain is thought to be due to reflux of urine from the bladder to the kidney, especially during micturition. The relationship between stent characteristics such as diameter, length, material, softness, position, and curl completeness and the stent-related symptoms have been investigated by several researchers.[4–13] However, the exact factors that affect the stent-related symptoms remain unclear. In the present study, we prospectively collected 59 patients who underwent uncomplicated URSL with the placement of a double-J stent. We evaluated the urinary symptoms by a specific questionnaire and clarified the predictive factors for stent-related symptoms by multivariate analysis.

Patients and Methods

After obtaining informed consent, we prospectively evaluated 59 eligible patients with ureteral stones diagnosed by intravenous urography who underwent URSL in a single institute from August 2007 to April 2008. All patients were anesthetized intravenously with propofol. The stones were disintegrated by a semirigid 6.5-Fr ureteroscope (Richard Wolf USA, Vernon Hills, IL, USA) with a holmium–YAG laser. One of three lengths of 6-Fr double-J ureteral stent was inserted at the end of the operation (22 cm, 24 cm or 26 cm). All of the stents were made of polyurethane (Cook Ireland Ltd., Limerick, Ireland). The double-J stent was inserted retrogradely via a guidewire under direct ureteroscopic vision at the end of the procedure. We chose the stent length randomly. The indwelled Foley catheter was removed and the patient was discharged on the next day after URSL. All procedures were completed without complications (no ureteral injury or intraoperative stone migration to the kidneys). After the operation, cephalexin (500 mg, 4 times daily) and acetaminophen (500 mg, 4 times daily) were prescribed for 4 days. The exclusion criteria included: (1) concomitant renal stones or residual stones on the postoperative plain film (KUB) and renal ultrasonography; (2) pre-procedural urological diseases that caused lower urinary tract symptoms or bladder pain, including prostate disease (benign prostate hypertrophy, chronic prostatitis, and prostate cancer), overactive bladder, interstitial cystitis, painful bladder syndrome, urinary incontinence, and urinary tract infection; (3) long-term medications with α-blockers, anticholinergics or analgesics; and (4) the presence of procedure-associated complications such as fragment migration to the kidneys, ureteral injury, urinary tract infection, or stent malposition.

One week after URSL, a plain (KUB) film and renal ultrasonography images were obtained at the clinic for all the patients to confirm the stent position and the presence of residual stones. All films were reviewed by a single urologist. In addition to the length of stent, four characteristics on the image were recorded: (1) the position of the proximal curl (in the upper pole or the renal pelvis); (2) the position of the distal curl (crossing the midline or not); (3) the completeness of the proximal curl; and (4) the completeness of the distal curl. At the same time, all patients were asked to complete the self-administered questionnaire in outpatient clinics to assess their symptoms in the period of stenting. The investigated symptoms included frequency, urgency, nocturia, urge incontinence, hematuria, flank pain, and bladder pain (see Appendix). To assess the severity of each symptom, the questions were adapted from the questionnaire of the International Prostate Symptoms Score (IPSS). The severity of flank and bladder pain was evaluated with a pain score, of 0–5, with 0 = pain, and 5 = the worst pain ever experienced.

Statistical analysis was performed with SAS version 9.1.3 (SAS Institute Inc., Cary, NC, USA). Two-tailed $p \leq 0.05$ was considered statistically significant. Continuous data were expressed as mean ± standard deviation unless otherwise

specified. Percentages were calculated for categorical variables. Descriptive analysis of all available variables was performed. In multivariate analysis, the commonly used proportional odds logistic regression model was fitted to the observed polychotomous categorical response with ordered categories. Each symptom question was originally scored as 0 for "no symptom" and 1–5 to indicate the chance of having the symptom, or its severity from low to high (Appendix). We re-classified the 0–5 symptom scores into three ordered grading categories as the polychotomous response variable: 1 = no symptom (for symptom score = 0); 2 = mild symptom (for symptom scores = 1 or 2); and 3 = severe symptom (for symptom scores = 3–5). Basic model-fitting techniques for (1) variable selection, (2) goodness-of-fit (GOF) assessment, and (3) regression diagnostics (e.g. test of the proportional odds assumption, residual analysis, detection of influential cases, and check for multicollinearity) were used in our regression analyses to ensure the quality of the results. In the stepwise variable selection, both the significant level for entry (SLE) and stay (SLS) were set to ≥ 0.15, and the covariates including age, sex, body weight, body height, stone size, stone position, operation time, stent length (22 cm, 24 cm or 26 cm), crossing midline of distal end (yes *vs.* no), position of proximal end (upper calyx *vs.* pelvis), curl of distal end (complete *vs.* incomplete), curl of proximal end (complete *vs.* incomplete) were considered. GOF measures, such as the percentage of concordant pairs, estimated area under the receiver operating characteristic curve, and the adjusted generalized R^2, and the GOF tests, including the deviance GOF test and Pearson χ^2 GOF test, were examined to assess the GOF of each fitted logistic regression model.

Table 1. Patient demographic and stent-related characteristics ($n = 59$)*

Variables	Value
Age (yr)	53.7 ± 12.9
Sex	
Male	22 (37.3)
Female	37 (62.7)
Body height (cm)	161.9 ± 7.9
Body weight (kg)	66.1 ± 13.3
Laterality	
Right side	35 (59.3)
Left side	24 (40.7)
Stone size (mm^2)	93.1 ± 39.5
Stone position	
Upper 1/3	26 (44.1)
Middle 1/3	9 (15.3)
Lower 1/3	24 (40.7)
Operation time (min)	40.6 ± 23.2
Double-J length	
22 cm	16 (27.1)
24 cm	17 (28.8)
26 cm	26 (44.1)
Distal end across midline	
Yes	34 (57.6)
No	25 (42.4)
Proximal end position	
Upper calyx	38 (64.4)
Renal pelvis	21 (35.6)
Proximal end curl	
Complete curl	51 (86.4)
Incomplete curl	8 (13.6)
Distal end curl	
Complete curl	50 (84.8)
Incomplete curl	9 (15.3)

**Data presented as n (%) or mean ± standard deviation.*

Results

The demographic and stent-related characteristics of the 59 patients are listed in Table 1. There were 22 male (37.3%) and 37 (62.7%) female subjects. The mean age was 53.7 ± 12.9 years. The mean body height and weight were 161.9 ± 7.9 cm (range, 145.9–178 cm) and 66.1 ± 13.3 kg (range, 54–95 kg), respectively. The stone was located in the right ureter in 35 (59.3%) patients and in the left ureter in 24 (40.7%). The mean stone size was 93.1 ± 39.5 mm^2, and mean operation time was 40.6 minutes.

The frequency distribution of double-J-related symptoms is shown in Table 2. The incidence of

Table 2. Frequency distribution of double-J-related symptoms ($n = 59$)*

Symptom	Grading					
	No symptom	Mild symptom		Severe symptom		
	0*	1	2	3	4	5
Frequency	8 (13.6)	5 (8.47)	18 (30.5)	6 (10.2)	13 (22.0)	9 (15.3)
Urgency	14 (23.7)	6 (10.2)	16 (27.1)	4 (6.8)	13 (22.0)	6 (10.2)
Urge incontinence	35 (59.3)	14 (23.7)	3 (5.1)	4 (6.8)	3 (5.1)	0 (0)
Nocturia	5 (8.5)	17 (28.8)	27 (45.8)	5 (8.5)	2 (3.4)	3 (5.1)
Flank pain	18 (30.5)	3 (5.1)	9 (15.3)	9 (15.3)	14 (23.7)	6 (10.2)
Urethral pain	18 (30.5)	2 (3.4)	8 (13.6)	11 (18.6)	14 (23.7)	6 (10.2)
Hematuria	12 (20.3)	5 (8.5)	1 (1.7)	25 (42.4)	16 (27.1)	0 (0)

**Data presented as n (%). These symptom scores from 0 to 5 were reclassified into three categories as indicated in the table subheadings. In polychotomous logistic regression analysis, "No symptom" was re-coded as 0, "Mild symptom" as 1, and "Severe symptom" as 2.*

the irritative symptoms was 91.5% for nocturia, 86.4% for frequency, 76.3% for urgency, and 40.7% for urge incontinence. The mean scores for individual symptoms were: 1.69 ± 1.61 (range, 0–5) for frequency; 1.46 ± 1.64 (range, 0–5) for urgency; 1.44 ± 1.34 (range, 0–5) for nocturia; and 0.86 ± 1.37 (range, 0–5) for urge incontinence. Bladder pain was presented in 41 of 59 (69.5%) patients with the same incidence of flank pain. Gross hematuria was noted in 47 (79.7%) patients. No patients needed to visit the emergency room due to severe stent-related symptoms or procedure-associated complications.

Multivariate analysis of the risk factors associated with each of the five lower urinary tract symptoms (frequency, urgency, urge incontinence, nocturia, and hematuria) in 59 patients is shown in Table 3. The 26-cm stent was independently associated with the severity of frequency, urgency and nocturia symptoms. The corresponding estimated odds ratios (ORs) were 4.638 [95% confidence interval (CI) = 1.59–13.53; $p = 0.0050$)], 4.126 (95% CI = 1.482–11.484; $p = 0.0067$), and 3.618 (95% CI = 0.996–13.15; $p = 0.0508$), respectively. Crossing the midline of the distal end was significantly associated with urge incontinence (OR = 4.767; 95% CI = 1.604–14.16; $p = 0.0049$). Finally, the 24-cm and 26-cm stents were both very strongly associated with severity of hematuria (OR = 18.081; 95% CI = 3.054–107.042; $p = 0.0014$ and OR = 12.683; 95% CI = 3.002–53.593; $p = 0.0006$, respectively). Crossing the midline of the distal end was significantly associated with bladder pain (OR = 8.475; 95% CI = 1.749–41.066; $p = 0.0079$). The variables of right side and body weight were not significantly related to flank pain ($p > 0.05$).

Discussion

Placement of a double-J ureteral stent has been widely used in urological surgery since it was first described by Zimskind in 1967.[14] Although it ensures urinary drainage, significant morbidity is associated with the placement of a ureteral stent. Joshi et al reported on the adverse effects of double-J stents, and have suggested that 80% of patients experience bothersome urinary symptoms and pain related to the stent.[1,2] Our results showed a similar prevalence. Stent-related urinary symptoms were thought to have been due to bladder irritation by the stent. Several studies have investigated associated factors that might cause urinary symptoms, but the results remain controversial.[4,5,7–13,15,16]

El-Nahas et al an analysis of factors responsible for ureteral-stent-associated discomfort. They enrolled patients with various diagnoses and treatment procedures. In addition, they coded symptoms by recording whether symptoms were present or not, which did not represent the exact

Table 3. Multivariate analyses of the risk factors associated with urinary tract symptoms (frequency, urgency, urge incontinence, nocturia), urethral pain, flank pain and hematuria in 59 patients

Covariate	Estimate	Standard error	Wald χ^2	*p*	OR (95% CI)
1. Nocturia (1, 2, 3)*					
Intercept 3	–2.2899	0.5496	17.3621	<0.0001	–
Intercept 2	1.9715	0.4980	15.6735	<0.0001	–
Length 26	1.2860	0.6584	3.8149	0.0500	3.618 (0.996–13.150)
2. Frequency (1, 2, 3)†					
Intercept 3	–0.7640	0.3636	4.4154	0.0356	–
Intercept 2	1.3918	0.4132	11.3479	0.0008	–
Length 26	1.5343	0.5463	7.8884	0.0050	4.638 (1.590–13.530)
3. Urgency (1, 2, 3)‡					
Intercept 3	–1.1185	0.3785	8.7337	0.0031	–
Intercept 2	0.6778	0.3535	3.6766	0.0552	–
Length 26	1.4172	0.5223	7.3622	0.0067	4.126 (1.482–11.484)
4. Urge incontinence (1, 2, 3)§					
Intercept 3	–2.9300	0.5522	28.1573	<0.0001	–
Intercept 2	–1.1255	0.3970	8.0367	0.0046	–
Cross midline	1.5616	0.5556	7.9000	0.0049	4.767 (1.604–14.160)
5. Urethral pain (1, 2, 3)‖					
Intercept 3	1.2864	1.1250	1.3075	0.2528	–
Intercept 2	3.9280	1.2586	9.7410	0.0018	–
Cross midline	1.2675	0.5473	5.36	0.0079	8.475 (1.749–41.066)

6. Flank pain (1, 2, 3)[¶]					
Intercept 3	–2.3214	1.3674	2.8819	0.0896	–
Intercept 2	–0.7668	1.3380	0.3285	0.5666	–
Body weight	0.0328	0.0196	2.8147	0.0934	1.033 (0.094–1.074)
Right side	–0.8972	0.5070	3.1315	0.0768	0.408 (0.151–1.101)
7. Hematuria (1, 2, 3)[#]					
Intercept 3	–0.8805	0.5157	2.9149	0.0878	–
Intercept 2	–0.1146	0.4897	0.0548	0.8149	–
Length 24	2.8949	0.9073	10.1793	0.0014	18.081 (3.054–107.042)
Length 26	2.5403	0.7353	11.9356	0.0006	12.683 (3.002–53.593)

**Proportional odds polychotomous logistic regression model: n = 59, score test of the proportional odds assumption p = 0.9595 > 0.05 (df = 1), percentage of concordant pairs = 39.7%, percentage of discordant pairs = 11.7%, adjusted generalized R^2 = 0.0896, deviance GOF test p = 0.9597 > 0.05 (df = 1), and Pearson GOF test p = 0.9595 > 0.05 (df = 1); [†]proportional odds polychotomous logistic regression model: n = 59, score test of the proportional odds assumption p = 0.4172 > 0.05 (df = 1), percentage of concordant pairs = 42.8%, percentage of discordant pairs = 10.8%, adjusted generalized R^2 = 0.1554, deviance GOF test p value = 0.4508 > 0.05 (df = 1), and Pearson GOF test p = 0.4347 > 0.05 (df = 1); [‡]proportional odds polychotomous logistic regression model: n = 59, score test of the proportional odds assumption p = 0.8821 > 0.05 (df = 1), percentage of concordant pairs = 40.8%, percentage of discordant pairs = 11.4%, adjusted generalized R^2 = 0.1406, deviance GOF test p = 0.8830 > 0.05 (df = 1), and Pearson GOF test p = 0.8827 > 0.05 (df = 1); [§]proportional odds polychotomous logistic regression model: n = 59, score test of the proportional odds assumption p = 0.1332 > 0.05 (df = 1), percentage of concordant pairs = 45.5%, percentage of discordant pairs = 11.3%, adjusted generalized R^2 = 0.1595, deviance GOF test p = 0.1737 > 0.05 (df = 1), and Pearson GOF test p = 0.1586 > 0.05 (df = 1); [‖]proportional odds polychotomous logistic regression model: n = 59, score test of the proportional odds assumption p = 0.8555 > 0.05 (df = 1), percentage of concordant pairs = 38.1%, percentage of discordant pairs = 12.0%, adjusted generalized R^2 = 0.0925, deviance GOF test p = 0.8576 > 0.05 (df = 1), and Pearson GOF test p = 0.8580 > 0.05 (df = 1); [¶]proportional odds polychotomous logistic regression model: n = 59, score test of the proportional odds assumption p = 0.3732 > 0.05 (df = 1), percentage of concordant pairs = 65.7%, percentage of discordant pairs = 33.8%, adjusted generalized R^2 = 0.1093, deviance GOF test p = 0.1731 > 0.05 (df = 1), and Pearson GOF test p = 0.3621 > 0.05 (df = 1); [#]proportional odds polychotomous logistic regression model: n = 59, score test of the proportional odds assumption p = 0.3399 > 0.05 (df = 1), percentage of concordant pairs = 64.6%, percentage of discordant pairs = 10.5%, adjusted generalized R^2 = 0.2727, deviance GOF test p = 0.4656 > 0.05 (df = 1), and Pearson GOF test p = 0.4738 > 0.05 (df = 1). OR = odds ratio; CI = confidence interval; GOF = goodness-of-fit.*

severity of stent-related symptoms. They used a logistic regression model for multivariate analysis and have concluded that the proper position of the stent coils and shorter stenting duration decrease patient discomfort.[16] We have demonstrated previously that stent length is associated with the position of the distal loop and the related urinary symptoms in a retrospective research, without analyzing perioperative factors.[13] In the present study, we prospectively recruited patients who underwent URSL, and analyzed all possible variables by the proportional odds logistic regression model to determine the factors that were significantly associated with stent-related symptoms. Basic model-fitting techniques for (1) variable selection, (2) GOF assessment, and (3) regression diagnostics were used in our regression analysis to ensure the quality of the results.

It is reasonable to postulate that an overlong stent with a longer intravesical segment might cause more irritation of the bladder, and consequently increase the severity of discomfort. A few previous studies have demonstrated results that are consistent with ours. Rane et al reported that stents crossing the midline of the bladder or those with incomplete loops at the lower end significantly increase morbidity. They have concluded that proper stent length and placement appropriate to each patient's ureteral length are necessary to improve comfort.[9] Liatsikos et al also compared the symptoms associated with placement of the proximal curl in the upper pole and renal pelvis. They have proposed that positioning of the proximal end of the double-J stent in the upper pole of the kidney appears to be better tolerated by patients than is standard insertion in the renal pelvis, in terms of urgency, dysuria and quality of life.[8] Al-Kandari et al also demonstrated that flank pain, urgency, dysuria and worsened quality of life are significantly more common among patients who have longer stents.[15] Some studies have revealed different results. Irani et al evaluated the urinary symptoms of 39 patients after inserting a 28-cm ureteral stent. Most of the patients could tolerate the stent-related discomfort.[11] The exact correlation between stent length and stent-related symptoms remains inconclusive. Our results demonstrated that a 26-cm stent was significantly associated with the severity of nocturia, frequency and urgency. Crossing the midline of the distal end had a significant impact on urge incontinence. Bladder pain could be independently predicted by crossing the midline of the distal end. Hematuria was significantly associated with 24-cm and 26-cm stents compared with 22-cm stents. These results yield useful information that help to clarify the issue.

Several studies have suggested methods to determine the correct stent length, including direct measurement of the ureter itself using a guidewire, an endocatheter ruler, formulas based on preoperative intravenous urography, and formulas based on patient height.[6,17–20] None of the methods have been proven accurate or applicable to clinical practice. Shah et al measured ureteral length using a ureteral catheter and have compared the measured length with the height of 25 patients.[19] The mean patient height was 164.8 cm (range, 156–180 cm) and ureteral length was 23.46 cm (range, 16–29 cm). Patient height did not correlate with ureteral length. Conversely, Pilcher et al found that patient height was correlated with ureteral length more accurately than direct endoluminal measurement in 35 patients. They have proposed the use of 22-cm stents for patients shorter than 178 cm, 24-cm stents for patients between 178 and193 cm, and 26-cm stents for patients taller than 193 cm. The main criticism of their study is that subjective symptom scores were not determined. Our results also indicated that the 22-cm stent was appropriate for the study objects whose mean body height was 161.9 cm (range, 145.9–178.0 cm). In addition, subjects treated with 22-cm stent experienced less stent-related symptoms compared with those treated with 24- and 26-cm stent.

The present study prospectively analyzed all clinically available parameters by multivariate analysis to establish the predictive factors for stent-related symptoms after uncomplicated URSL. A small number of patients and the non-randomized design were the major limitations of the study.

However, our results provide useful information for endourologists who are choosing an appropriate double-J stent after uncomplicated URSL.

In conclusion, the length of stent and midline crossing had a significant effect on stent-related urinary symptoms during stenting after uncomplicated URSL. The choice of an appropriate length of stent might be the most important issue that we should consider to reduce the severity of stent-related symptoms.

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Appendix. The questionnaire was used to assess the symptoms following stent insertion:

Q1. Over the past week, how often have you had to urinate again less than 2 hours after you finished urinating?
(0) Not at all, (1) Less than one in five times, (2) Less than half the time, (3) About half the time,
(4) More than half the time, (5) Almost always

Q2. Over the past week, how often have you found it difficult to postpone urination?
(0) Not at all, (1) Less than one in five times, (2) Less than half the time, (3) About half the time,
(4) More than half the time, (5) Almost always

Q3. Over the past week, how many times did you most typically get up to urinate from the time you went to bed until the time you got up in the morning?
(0) Never, (1) Once, (2) Twice, (3) Three times, (4) Four times, (5) Five times or more

Q4. Over the past week, how often have you had urine leakage before you can reach the toilet?
(0) Not at all, (1) Less than one in five times, (2) Less than half the time, (3) About half the time,
(4) More than half the time, (5) Almost always

Q5. Over the past week, have you had any bladder pain? Please try to grade the severity on a scale of 0 to 5 (with 0 = no pain and 5 = the worst pain ever experienced).
(0) (1) (2) (3) (4) (5)

Q6. Over the past week, have you ever had any flank pain? Please try to grade the severity on a scale of 0 to 5 (with 0 = no pain and 5 = the worst pain ever experienced).
(0) (1) (2) (3) (4) (5)

Q7. Over the past week, how often have you ever had hematuria?
(0) Not at all, (1) Less than one in five times, (2) Less than half the time, (3) About half the time,
(4) More than half the time, (5) Almost always