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Original Article

The optimal stent pusher position to achieve successful ureteral stent insertion under fluoroscopic guidance

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Abstract: *Objective:* To examine factors to predict the optimal stent pusher position when inserting ureteral stents under fluoroscopy.
Methods: We retrospectively reviewed 327 patients who underwent ureteral stent insertion. We considered the pubic bone as a useful anatomical landmark to insert ureteral stents under fluoroscopic guidance. Thus, we categorized patients into three groups (proximal, middle, and distal groups) according to the position of the radiopaque tip of the push catheter when inserting the ureteral stent. Success was defined as a completely curled ureteral stent tail. We compared stent insertion success rates among the three groups. A multivariate analysis was performed to identify the factors affecting stent insertion success.
Results: In men, 36 (63.2%) cases were deemed successful in the proximal group compared with 40 (80.0%) cases in the middle group and 12 (20.7%) cases in the distal group ($p<0.001$). In women, 26 (45.6%) cases were deemed successful in the proximal group compared with 54 (98.2%) cases in the middle group and 38 (76.0%) cases in the distal group ($p<0.001$). With the multivariate analysis, the stent pusher position was the most significant factor influencing successful stent insertion (men: odds ratio 6.00, 95% confidence interval 2.66—13.51, $p<0.001$; women: odds ratio 37.80, 95% confidence interval 4.94—289.22, $p<0.001$).
Conclusion: The position of the stent pusher affects stent insertion success. The middle of the pubic symphysis is the optimal position for the radiopaque tip of the pusher when inserting ureteral stents under fluoroscopic guidance.

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1. Introduction

Since Zimskind et al. [1] introduced ureteral stents in 1967, such stents have become widely used for the maintenance of renal function, pain relief, and the treatment of urinary tract infection. Cystoscopic retrograde stent placement has been widely reported [2,3]. However, because of the rigidity and large diameter of a cystoscope, patients experience pain, and some patients require anesthesia. McFarlane et al. [3] have since introduced their technique, which involves ureteral stent insertion using flexible cystoscopy and fluoroscopy. Various other methods to relieve pain have also been introduced [4—6]. When inserting a guidewire into the ureter using a cystoscope and inserting a stent under fluoroscopy, the positions of the ureteral stent and pusher are confirmed by fluoroscopy. If the pusher is not in the correct position, the stent will migrate or remain in the urethra. Thus, the position of the pusher when inserting the ureteral stent under fluoroscopy is important. However, the optimal pusher position is unclear. Therefore, this retrospective study aimed to identify factors to predict the optimal pusher position when inserting ureteral stents under fluoroscopic guidance.

2. Patients and methods

This study was approved by the Osaka Saiseikai Izuo Hospital review board (authorization number: R02-1101) and obtained the informed consents of the patients for treatment and data publication. All patients who underwent placement of a ureteral stent from April 2017 to April 2020 were included in this study. The exclusion criteria were vaginal vault eversion beyond the introitus and incomplete or impossible placement of a ureteral stent because of severe ureteral or urethral stenosis. In total, 327 patients were enrolled and retrospectively analyzed.

We categorized the patients into three groups (the proximal group, the middle group, and the distal group) according to the position of the radiopaque tip of the push catheter when inserting the ureteral stent under fluoroscopy; this position was termed the "release point". The pubic symphysis is divided into three equal parts. In the proximal group, the position of the radiopaque tip of the push catheter was on the proximal side of the pubic symphysis (Fig. 1A). In the middle group, the position of the radiopaque tip of the push catheter was in the middle of the pubic symphysis (Fig. 1B). In the distal group, the position of the radiopaque tip of the push catheter was on the distal side of the pubic symphysis (Fig. 1C). Success was defined when the stent tail completely curled immediately after the guidewire was removed (Fig. 1D). An incompletely curled ureteral stent tail indicated stent insertion failure (Fig. 1E and F). Fig. 1E shows stent migration into the ureter, and Fig. 1F shows the stent remaining in the urethra, both of which were defined as stent insertion failure. In cases of stent insertion failure, the ureteral stent was withdrawn using a stent string without a cystoscope or ureteroscope, and the ureteral stent was placed again properly.

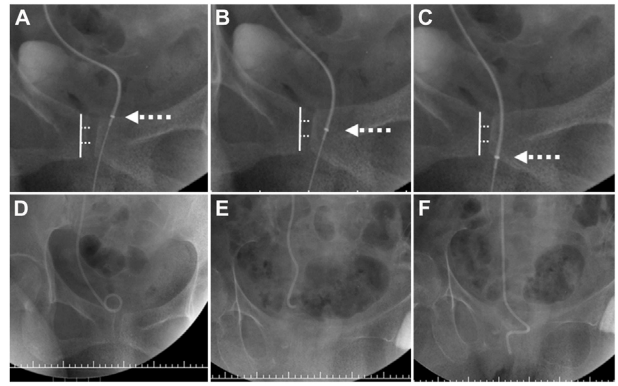

Figure 1 Classification of the position of the radiopaque tip of the push catheter and definition of successful stent insertion: (A—C) The pubic symphysis was divided into three equal parts: (A) In the proximal group, the radiopaque tip of the push catheter was on the proximal side of the pubic symphysis; (B) In the middle group, the radiopaque tip of the push catheter was in the middle of the pubic symphysis; (C) In the distal group, the radiopaque tip of the push catheter was on the distal side of the pubic symphysis; (D) A completely curled ureteral stent tail indicated successful stent insertion; (E) Stent migration indicated stent insertion failure; (F) Stent remaining in the urethra indicated stent insertion failure.

We inserted a ureteral stent according to the following procedure. First, we used a cystoscope and inserted a guidewire (Nitinol wire with a hydrophilic tip, a diameter of 0.89 mm, and a length of 150 cm) into the ureter. At that time, we identified the position of the ureteral orifice under fluoroscopy, and measured the distance from the inferior margin of the pubic symphysis to the ureteral orifice (DIU) using X-ray images taken during stent placement (Fig. 2). Next, we removed the cystoscope, and the stent was advanced over the guidewire with the stent pusher. We considered the pubic bone as a useful anatomical landmark to insert the ureteral stent with

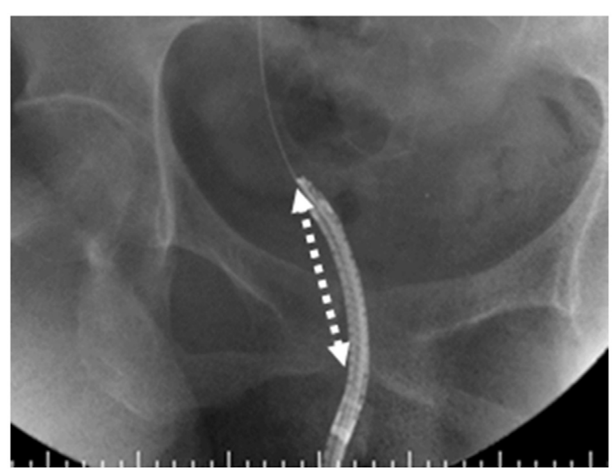

Figure 2 The distance from the inferior border of the pubic symphysis to the ureteral orifice.

complete curling under fluoroscopy. Thus, we confirmed the position of the radiopaque tip of the push catheter using the pubic bone as a landmark, and the guidewire was removed. At that time, we took X-ray images without moving the position of the stent pusher.

We inserted the same ureteral stent (Inlay Optima; C. R. Bard Inc., New Jersey, NJ, USA) and the same stent pusher (Push Catheter with Radiopaque Ban; C. R. Bard Inc., New Jersey, NJ, USA). The distance from the radiopaque band to the tip of the stent pusher was 3—4 mm. The diameter of all ureteral stents was 6 Fr, and the length was 24 cm or 26 cm according to the surgeon's discretion.

We assessed several parameters, including prostate volume (PV) and intravesical prostatic protrusion (IPP), by transabdominal ultrasonography [7]. To evaluate the correlation between these characteristics and the success of ureteral stent insertion, we evaluated them separately due to the different anatomical structures of the lower urinary tract in males and females. Patients' demographics, including age, height, body weight, body mass index, stent side, indication for ureteral stent insertion, DIU, PV, IPP, and stent insertion success rate, were reviewed and compared among the three groups using either the Kruskal—Wallis test or the χ^2 test. Furthermore, a multivariate analysis was performed using a logistic regression model to identify the most significant factors affecting the success of stent insertion. IBM SPSS Statistics V21.0 software (IBM Corp., Armonk, NY, USA) was used for statistical analysis, and the significance level was set at $p<0.05$.

3. Results

Table 1 shows patients' demographic data. In men, 36 (63.2%) cases of stent insertion were deemed successful in the proximal group compared with 40 (80.0%) cases in the middle group and 12 (20.7%) cases in the distal group ($p<0.001$). Twenty-one (36.8%) patients demonstrated stent insertion failure (migration into the ureter in 18 patients; stent remaining in the urethra in three patients) in the proximal group compared with 10 (20.0%) patients (migration into the ureter in one patient; stent remaining in the urethra in nine patients) in the middle group, and 46 (79.3%) patients (migration into the ureter in one patient; stent remaining in the urethra in 45 patients) in the distal group. In women, 26 (45.6%) patients demonstrated stent insertion success in the proximal group compared with 54 (98.2%) patients in the middle group and 38 (76.0%) patients in the distal group ($p<0.001$). Thirty-one (54.4%) patients demonstrated stent insertion failure (migration into the ureter in 31 patients; stent remaining in the urethra in 0 patient) in the proximal group compared with 1 (1.8%) patient (migration into the ureter in 1 patient; stent remaining in the urethra in 0 patient) in the middle group and 12 (24.0%) patients (migration into the ureter in 0 patient; stent remaining in the urethra in 12 patients) in the distal group.

Table 2 shows the results of the univariate and multivariate analyses performed to evaluate the correlation between the success of stent insertion and patient parameters. In men, PV significantly affected the success of

Table 1 The demographics of patients in each group.

Demographic	Men				Women			
	Proximal	Middle	Distal	*p*-Value	Proximal	Middle	Distal	*p*-Value
Patient, *n*	57	50	58	NA	57	55	50	NA
Age, year	63.9±16.2	63.1±15.5	62.6±14.7	0.86	73.5±13.4	73.7±15.5	69.7±16.4	0.44
Body height, m	1.64±0.07	1.65±0.08	1.65±0.07	0.55	1.49±0.06	1.50±0.07	1.48±0.07	0.74
Body weight, kg	64.5±13.9	66.1±12.6	65.6±11.1	0.54	47.8±10.3	50.3±10.9	48.6±10.4	0.31
BMI, kg/m^2	23.9±4.3	24.3±4.3	24.0±3.8	0.83	21.4±4.3	22.2±4.5	22.1±4.3	0.45
Side (stent placement)				0.64				0.27
Right	23 (40.4)	19 (38.0)	27 (46.6)		26 (45.6)	33 (60.0)	24 (48.0)	
Left	34 (59.6)	31 (62.0)	31 (53.4)		31 (54.4)	22 (40.0)	26 (52.0)	
Indication (stent placement)				0.46				0.02
Ureteroscopy	51 (89.5)	41 (82.0)	54 (93.1)		44 (77.2)	26 (47.3)	36 (72.0)	
Stricture	4 (7.0)	5 (10.0)	2 (3.4)		5 (8.8)	6 (10.9)	8 (16.0)	
Ureteral stone	2 (3.5)	4 (8.0)	2 (3.4)		8 (14.0)	23 (41.8)	6 (12.0)	
DIU, mm	47.4±9.8	47.6±9.4	47.6±8.1	0.98	37.1±11.1	39.2±13.8	36.5±9.6	0.67
PV, mL	25.6±12.6	22.5±10.6	23.9±12.1	0.51				NA
IPP, mm	4.5±4.2	3.8±3.3	3.9±4.0	0.69				NA
Stent placement				<0.001				<0.001
Success	36 (63.2)	40 (80.0)	12 (20.7)		26 (45.6)	54 (98.2)	38 (76.0)	
Failure	21 (36.8)	10 (20.0)	46 (79.3)		31 (54.4)	1 (1.8)	12 (24.0)	
Failure classification				NA				NA
Migration into the ureter	18	1	1		31	1	0	
Remaining in the urethra	3	9	45		0	0	12	

BMI, body mass index; DIU, distance from the inferior margin of the pubic symphysis to the ureteral orifice; PV, prostate volume; IPP, intravesical prostatic protrusion; NA, not available.
Note: the data are presented as *n*, *n* (%) or mean±standard deviation.

Table 2 Univariate and multivariate analysis demonstrating factors predicting successful stent placement.

Predicting factor	Univariate analysis	Multivariate analysis		
	p-Value	OR	95 % CI	*p*-Value
Men				
Age	0.35			
Height	0.99			
Body weight	0.08			
BMI	0.03	0.98	0.95–1.01	0.250
Side (stent placement)	0.31			
Release point (middle *vs.* others)	<0.001	6.00	2.66–13.51	<0.001
DIU	0.17			
PV	0.046	0.91	0.83–0.99	0.030
IPP	0.12			
Women				
Age	0.14			
Height	0.73			
Body weight	0.58			
BMI	0.44			
Side (stent placement)	0.02	1.92	0.87–4.27	0.110
Release point (middle *vs.* others)	<0.001	37.80	4.94–289.22	<0.001
DIU	0.02	1.04	1.00–1.08	0.038

BMI, body mass index; DIU, distance from the inferior margin of the pubic symphysis to the ureteral orifice; PV, prostate volume; IPP, intravesical prostatic protrusion; OR, odds ratio; CI, confidence interval.

stent insertion (odds ratio [OR] 0.91, 95% CI 0.83–0.99, $p=0.030$). However, the release point (middle *vs.* others) was the most significant factor (OR 6.00, 95% CI 2.66–13.51, $p<0.001$) influencing the success of stent insertion. In women, DIU significantly affected the success of stent insertion (OR 1.04, 95% CI 1.00–1.08, $p=0.038$). However, the release point (middle *vs.* others) was the most significant factor affecting the success of stent insertion (OR 37.80, 95% CI 4.94–289.22, $p<0.001$).

4. Discussion

With a multivariate analysis, we found that the position of the pusher is the most important factor to consider when inserting ureteral stents. The correct position of the radiopaque tip of the push catheter when inserting ureteral stents under fluoroscopy is the middle of the pubic symphysis. In this study, when the release point was the middle of the pubic symphysis, the success rate of stent insertion was 80.0% in males and 98.2% in females. This method does not require any specialized techniques. To the best of our knowledge, no previous studies have identified a useful anatomical landmark to insert completely curled ureteral stents under fluoroscopic guidance. This study is the first to identify the correct pusher position when inserting ureteral stents under fluoroscopy.

Mardis et al. [8] introduced the technique of stent placement. They reported endoscopic retrograde insertion, percutaneous antegrade insertion, and open operative insertion. Although various techniques of stent placement have been used, the cystoscopic technique is the most common, and many methods to improve the cystoscopic technique have been introduced. Yedlicka et al. [4] introduced the technique of ureteral stent retrograde exchange with a snare catheter. de Baere et al. [9] introduced ureteral stent exchange under fluoroscopic guidance with a guidewire lasso technique. Moreover, Park et al. [5] introduced four techniques, namely the simple snare technique, the modified snare technique, the guidewire lasso technique, and the direct grasping technique. Kawahara et al. [10] introduced the technique of stent exchange using a crochet hook under fluoroscopic guidance. At our hospital, we used a flexible cystoscope to insert a guidewire into the ureter and advanced the ureteral stent over the guidewire under fluoroscopic guidance because we considered that the use of a flexible cystoscope is less painful than the use of a rigid cystoscope. Jeong et al. [11] evaluated the effectiveness of ureteral stent removal by flexible cystoscopy with regards to pain and satisfaction in young men. They reported that ureteral stent removal using flexible cystoscopy may offer advantages for pain and satisfaction in young male patients. Therefore, we used a flexible cystoscope and fluoroscopy when inserting ureteral stents in this study.

Inadequate distal curl is a risk factor for stent migration [12]. Furthermore, when a ureteral stent crosses the bladder midline, it may lead to worse urinary symptoms [13,14]. Thus, it is important that the ureteral stent is properly placed. Moreover, we consider our method useful for residents because it does not require any specialized techniques. Furthermore, our method is useful for experienced endourologists too. Dellis et al. [16] reported that standardizing the surgical technique of ureteral stent placement and exchange could result in a significant improvement in total operating time and fluoroscopy time. The position of the stent pusher was not standardized in their study, but we considered that standardization of the stent pusher position may further improve operating time and fluoroscopy time.

This study reveals that the optimal pusher position when inserting ureteral stents under fluoroscopic guidance is the middle of the pubic symphysis. With this approach, the success rates of stent insertion were 80.0% and 98.2% in men and women, respectively. This method is easy and useful; however, the success rates were still not 100%. The location of the ureteral orifice differs between men and women and among individuals of the same sex [15]. Hwang et al. [15] warned endourologists to consider the anatomical differences between men and women during fluoroscopy-guided procedures. Therefore, we considered that the anatomical differences in the ureteral orifice position between men and women and among individuals of the same sex could affect the results of this study. Furthermore, anatomical differences in PV and IPP might have also affected the results. This may be the reason why men demonstrated a lower stent insertion success rate compared with women. We excluded patients with vaginal vault eversion beyond the introitus because inserting stents in patients with severe pelvic organ prolapse carries the risk of stent migration. Therefore, there is no doubt that the surest way to insert a stent in all patients is to look at the stent under a cystoscope.

This study has some limitations that should be noted. First, it was a retrospective and non-randomized trial. Second, we used one type of 6 Fr ureteral stent, and did not use other types of stents, such as the 5 Fr or 8 Fr stent. It is necessary to verify the results using other stents than 6 Fr stents because the coiling pattern varies among stents. We wanted to exclude the influence of using different types of stents; however, we suggest that future studies should involve randomization and use of various types of stents.

5. Conclusion

We consider that our method of stent insertion using the pubic symphysis under fluoroscopic guidance is useful and simple. We believe that good indications for this procedure are the possibility of placing a ureteral stent, the absence of severe pelvic organ prolapse, and the absence of severe ureteral or urethral stenosis. The middle of the pubic symphysis is the optimal position for the radiopaque tip of the push catheter when inserting ureteral stents under fluoroscopy.

Author contributions

Study concept and design: Makoto Taguchi.
Data acquisition: Makoto Taguchi, Kaneki Yasuda.
Data analysis: Makoto Taguchi, Hidefumi Kinoshita.
Drafting of manuscript: Makoto Taguchi.
Critical revision of the manuscript: Hidefumi Kinoshita.

Conflicts of interest

The authors declare no conflict of interest.

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