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# Retrograde balloon dilation as a therapeutic option for post-gynecologic surgery ureteral stricture followed by ureteroureterostomy: a comparative study regarding stricture length

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**Background:** To evaluate the success rate of balloon dilation and the factors possibly influencing the outcomes of balloon dilation for the ureteric strictured portion of ureteroureterostomy (UUS) site in patients with post-gynecologic surgeries.
**Methods:** A single institution data base was screened for the patients who received balloon dilation for a treatment of ureteral stricture diagnosed after gynecologic surgery. Overall 114 patients underwent primary intra-operative UUS due to ureteral injury during gynecologic surgery. Among them, 102 patients received balloon dilation, and their medical records were retrospectively reviewed. Success of balloon dilation was defined as the condition that requires no further clinical interventions after 6 months from balloon dilation.
**Results:** The ureter injury rate of women treated with open radical abdominal hysterectomy was highest (32 cases, 31.4%). 60 patients (60.8%) showed successful outcomes regarding dilation. All patients underwent technically successful dilation with a full expansion of balloon during the procedure, but 40 patients (39.2%) were clinically unsuccessful as they showed a recurrence of ureteral stricture on the previous balloon dilation site after the first dilation procedure. Univariate logistic regression analyses showed that stricture length >2 cm was a significant predictor of successful dilation (odds ratio, 0.751; 95% confidence interval, 0.634-0.901; *p*-value, 0.030), but it failed to achieve independent predictor status in multivariate analysis.
**Conclusion:** Balloon dilation can an effective alternative treatment option for strictured portion of the primary UUS in post-gynecologic surgery patients when its length is <2 cm.

**Keywords**: Gynecologic surgery; Postoperative complications; Surgical management; Ureter

## INTRODUCTION

The clinical definition of ureteral stricture is a narrowing of the ureter, which results in a functional hindrance or obstruction of urinary flow [1]. Depending on its site, ureteral stricture causes stretching of the collecting system, which consequently manifests as renal colic and potentially permanent renal damages [1,2].

The rate of pelvic surgeries due to either benign or malignant diseases has soared in worldwide, increasing the risk of intra-operative ureteral injury subsequently, gynecologic surgery of which accounted for 52-82% of the iatrogenic ureteral injury types in the previous studies [3,4]. According to a study published more recently, the ureteral injury incidence during gynecologic laparoscopy ranged from <1% to 25% [5]. Furthermore, only 30-50% of intra-operative ureteral injuries were dia-

gnosed in the acute settings [6], and primary ureteroureterostomy (UUS) is a feasible therapeutic option for small size (<3 cm) injuries of the mid to upper ureter [1]. Although UUS shows a high success rate and relatively low adverse events compared to other urological interventions, a small portion of patients experiences late ureteric stricture, which requires additional treatments to regain adequate urinary flow [7,8]. There are several treatment methods for ureteral stricture including chronic ureteral stent exchanges, balloon dilation, and surgical intervention of UUS or ureteroneocystostomy (UNC). Among these modalities, the success rate of balloon dilation for ureteral stricture recurred after UUS has been rarely reported, presumably because performing balloon dilation at the surgical sites may increase the risk of ureteral rupture. Nevertheless, Helfand et al. [9] have shown promise in undergoing balloon dilation for the patients with the stricture length <3 cm, although it was only applied to the post-kidney transplant patients. With this regard, our study primarily aimed to present and evaluate a series of balloon dilation cases for ureteral stricture patients who previously received primary UUS due to gynecologic surgery. Also, the secondary objective of the current study was to analyze the factors possibly influencing the therapeutic outcomes of balloon dilation.

## MATERIALS AND METHODS

### 1. Patient selection and study design

An approval of study was obtained from the Institutional Review Board (2018-08-019-001), and written informed consent regarding use of the clinical records was received from all study cohorts before inclusion to the study. A single institution data base was screened for the patients who underwent balloon dilation from May, 2005 to January, 2017 for a treatment of ureteral stricture diagnosed after gynecologic surgery. Overall 113,295 patients underwent gynecologic surgery during the corresponding period. Among them, total 155 cases of ureteral injuries were observed intraoperatively and all of the corresponding patients underwent primary repairs whereas 41 patients received UNC and the other 114 patients underwent UUS. Types of ureteral injuries such as transection, avulsion, puncture, and so on were not analyzed in this study due to limited data. In addition, the patients who presented with

urinary tract injuries after gynecologic surgeries were not included in the current study cohort. Among the 105 UUS received patients, 102 patients (89.5%) showed post-repair ureteral strictures and these 102 patients were retrospectively reviewed. The evaluated pre- and post-operative factors include the site of ureteral injury, etiologic cause of ureteral injury (types of gynecologic surgery), success and failure rate of UUS, duration between UUS and therapeutic balloon dilation, stricture characteristics, and follow-up after balloon dilation. Technique of balloon dilation was considered successful if the urologist was able to pass a guide wire and inflate the balloon through the structured portion of ureter. Clinical success of balloon dilation was defined as the condition that requires no further clinical interventions such as prolonged double J ureteral stent indwelling and revision of UUS or UNC after 12 months from balloon dilation. To diagnose clinical success of balloon dilation, all balloon dilation received patients underwent regular examinations of serum creatinine, intravenous pyelography and kidney ultrasonography during follow-up.

### 2. Diagnosis of ureteral stricture after primary UUS and balloon dilation

The cohorts underwent clinical evaluations of serum creatinine and kidney ultrasonography for every visit to urology clinic. In cases of elevated serum creatinine or hydroneprhosis on kidney ultrasonography, retrograde pyelography was performed for confirmative diagnosis of ureteral stricture. To neglect the possibility of malignant stricture of ureter, regular examination for gynecologic malignancy including positron emission tomography/computed tomography was performed during the follow up period.

For balloon dilation, 7.5 Fr (Wolf, France) ureteroscope was introduced into the ureter with stricture and a 5 Fr catheter with a hydrophilic 0.035-inch guide-wire (Terumo, Belgium) was inserted through the working channel of ureteroscope until it reached to the stricture segment. Then, the guide-wire was passed through the stricture portion of the ureter and a 5 mm diameter balloon catheter was moved along the guide-wire and inflated at 12 atmosphere (atm) over 5 minutes. Only regular type balloon was used for dilation and no cutting type balloon was used in any cases. After deflation of the balloon, a 6 Fr. double J ureteral stent was placed and it was maintained for 12 weeks.

## 3. Statistical analyses

All statistical analyses of the cohorts' clinical data were undertaken using IBM SPSS version 24.0 (IBM Co., Armonk, NY, USA) and $p$-values were considered significant when it was less than 0.05. Means and standard deviations were presented for continuous variables and proportions were used for categorical variables. The chi-square test, Mann-Whitney U test or an independent t-test were used to analyze the clinical differences between balloon dilation successful group and unsuccessful groups. Multivariate logistic regression analysis was performed to evaluate the factors influencing the success of balloon dilation. For statistical analysis, we considered all technically and clinically unsuccessful balloon dilations were categorized as unsuccessful entity.

## RESULTS

### 1. Gynecologic disease and ureteral injury

The overall urinary tract injury rates during gynecologic surgery were 0.5% and among them, bladder injury patients were 438 cases (73.9%), which was significantly higher than the ureteral injury cases (155 cases, 26.1%). The frequency of ureteral injury following gynecologic surgery was approximately 0.1%, with a higher percentage of injuries occurring during abdomi-

nal hysterectomies and myomectomies. The median follow-up was 13 months. The most common site of ureteral injury was mid-ureter level (67.1%) that was profoundly higher than 18.7% and 14.2% of proximal and distal ureter, respectively. The ureter injury rate of women treated with open radical abdominal hysterectomy was highest (32 cases, 31.4%), and 26 cases (25.5%) of ureteral injury was attributed to open myomectomy, which made the open surgeries account for more than 50% of the whole ureteral injury cases (Table 1). For laparoscopic myomectomy, 22 patients were noted with injured ureters, which revealed the greatest ureteral injury rate among laparoscopic surgeries. Moreover, laparoscopic salphingo-oophorectomy and laparoscopic radical vaginal hysterectomy had 15 and 7 patients with ureteral injuries, respectively (Table 2). All of the corresponding ureteral injury patients underwent primary intra-operative UUS during pelvic surgery. In addition, among 155 cases of ureteral injuries occurred during gynecologic surgery, 78 patients (50.3%) had a history of previous abdominopelvic surgeries and 128 patients (82.6%) presented with severe adhesions between ureter and other pelvic anatomical structures. For the treatment of ureteral stricture occurred after primary UUS, three patients out of 105 ureteral stricture patients underwent only conservative therapy by performing 6 Fr size ureteral stent placement with duration of 12 weeks and it resolved stricture (Table 1, 3).

**Table 1.** Gynecologic surgeries and injuries of urinary tract

| Subject | Number of patients (%) |
|---|---|
| Total number of gynecologic surgery patients | 113,295 |
| Urinary tract injuries | 593/113,295 (0.5) |
|   Bladder injury | 438 (0.4) |
|   Ureter injury | 155 (0.1) |
|     Stricture location | |
|       Proximal | 29 (18.7) |
|       Mid | 104 (67.1) |
|       Distal | 22 (14.2) |
|     Intraoperative primary repair | |
|       UUS | 114 (73.5) |
|         Ureteral stricture occurred after UUS | 105/114 (92.1) |
|           Treated with ureteral stent (no balloon dilation performed) | 3/105 (2.9) |
|           Treated with balloon dilation | 102/105 (97.1) |
|       UNC | 41 (26.5) |

Values are presented as number (%).
UUS, ureteroureterostomy; UNC, ureteroneocystostomy.

**Table 2.** Gynecologic surgeries that caused ureteral injury and subsequent UUS

| Types of gynecologic surgery | Number of patients (%) |
|---|---|
| Robotic surgery | |
|   Robot assisted radical vaginal hysterectomy | 0 (0.0) |
|   Robot assisted myomectomy | 0 (0.0) |
| Laparoscopic surgery | |
|   Laparoscopic radical vaginal hysterectomy | 7 (6.9) |
|   Laparoscopic myomectomy | 22 (21.5) |
|   Laparoscopic salphingo-oophorectomy | 15 (14.7) |
| Open surgery | |
|   Radical abdominal hysterectomy | 32 (31.4) |
|   Myomectomy | 26 (25.5) |
|   Cesarean section | 0 (0.0) |

Values are presented as number (%).
UUS, ureteroureterostomy.

**Table 3.** Logistic regression analysis for the predictors of ureteral stricture after primary UUS

| Predictor | OR (95% CI) | $p$-value |
|---|---|---|
| Univariate analysis | | |
|   History of previous abdominal surgery | 1.020 (1.003-1.816) | 0.040 |
|   Severe adhesions between ureter and adjacent tissues | 1.331 (1.065-2.001) | |
|   Surgery types | | |
|     Open UUS | Reference | 0.021 |
|     Laparoscopic UUS | 4.170 (0.932-8.014) | 0.325 |
| Multivariate analysis | | |
|   History of previous abdominal surgery | 1.405 (0.870-1.527) | 0.186 |
|   Severe adhesions between ureter and adjacent tissues | 1.052 (1.002-1.210) | 0.047 |

UUS, ureteroureterostomy; OR, odds ratio; CI, confidence interval.

**Table 4.** Comparisons between clinical factors of initial balloon dilation successful and unsuccessful groups (n=102)

| Clinical factor | DSG | DUG | $p$-value |
|---|---|---|---|
| No. of patients | 62 (60.8) | 40 (39.2) | |
| Age (yr) | 44.8±6.0 (35-55) | 44.7±5.3 (34-53) | 0.921 |
| Length of stricture (cm), median (range) | 1.45 (0.8-4.0) | 2.7 (1.5-4.5) | 0.002 |
| Stricture length >2 cm | 4 (6.5) | 32 (80.0) | 0.001 |
| Previous ureteral stent insertion | 36 (58.1) | 24 (60.0) | 0.553 |
| Duration between UUS and BD (mon) | 49.3±7.5 | 47.1±8.2 | 0.117 |
| Stricture location | | | 0.980 |
|   Proximal | 11 (17.7) | 8 (20.0) | |
|   Mid | 43 (69.4) | 26 (65.0) | |
|   Distal | 8 (12.9) | 6 (15.0) | |
|   Multiple | 0 (0.0) | 0 (0.0) | |
| BMI (kg/m$^2$) | 21.3±2.4 | 22.4±3.6 | 0.877 |
| DM | 7 (11.3) | 5 (12.5) | 0.062 |
| Recurrence of gynecologic malignancy | 0 (0.0) | 0 (0.0) | |

Values are presented mean±standard deviation or number (%).
UUS, ureteroureterostomy; BD, balloon dilation; DSG, balloon dilation successful group; DUG, balloon dilation unsuccessful group; BMI, body mass index; DM, diabetes mellitus.

**Table 5.** Logistic regression analysis for the predictors of successful balloon dilation

| Clinical factor | Univariate | | | Multivariate | | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | $p$-value | OR | 95% CI | $p$-value |
| Age | 1.029 | 0.887-1.029 | 0.705 | | | |
| Stricture length >2 cm | 0.751 | 0.634-0.901 | 0.030 | 0.951 | 0.805-1.002 | 0.078 |
| Stricture location | 2.166 | 0.551-8.514 | 0.269 | | | |
| Previous ureteral stent insertion | 1.332 | 0.709-2.330 | 0.473 | | | |
| Obesity (BMI >30 kg/m$^2$) | 2.015 | 0.609-1.769 | 0.057 | | | |
| DM | 1.037 | 0.887-1.154 | 0.998 | | | |

OR, odds ratio; CI, confidence interval; BMI, body mass index; DM, diabetes mellitus.

## 2. Balloon dilation

Table 4 shows the results of balloon dilation. Total 102 patients, who underwent primary intra-operative UUS due to pelvic injury-caused ureteral injury, received balloon dilation, and 60 patients (60.8%) showed successful outcomes regarding dilation. No patient was assigned as technically unsuccessful dilation category as passage of guide-wires and balloon dilatation through the stricture portion were properly made as intended. Although all patients were gone through technically successful dilation with a full expansion of balloon during the procedure, 40 patients (39.2%) were clinically unsuccessful as they showed a recurrence of ureteral stricture on previous balloon dilation site after a certain period from the first dilation procedure. There were no significant differences between the balloon dilation successful and unsuccessful groups in terms of patients' age, duration between UUS and balloon dilation, location of stricture, body mass index and diabetes mellitus prevalence (Table 4). The successful balloon dilation group had 58.1% of the patients underwent ureteral stent indwelling before balloon dilation, and the unsuccessful group had 60.0% of previous stent insertion rate ($p$=0.553). In addition, the duration of ureteral stent insertion, performed prior to the balloon dilation, was 12 weeks in every stented patient. During the follow-up, no patient showed a recurrence of gynecology malignancy. Furthermore, the balloon dilation successful group showed 1.45 cm of median stricture length, which was significantly shorter compared to 2.7 cm of the unsuccessful group ($p$=0.002). Regarding stricture location, the balloon dilation unsuccessful group showed a slightly higher portion of patients with distal ureter stricture (15.0%) compared to 12.9% of the successful group, though it was statistically insignificant ($p$=0.980). Since there was no patient who had multiple ureteral injuries during previous gynecologic sur-

gery, ureteral strictures at multiple locations were not observed in any patients. Among the balloon dilation unsuccessful group, 6 patients with distal ureter stricture underwent a surgery to undo the previous UUS and make a new UNC. Another 24 patients who had a stricture portion at proximal or mid ureter received the second balloon dilation, which eventually resolved the ureteral stricture within 22 patients. The second balloon dilation procedure was methodologically the same as the previous procedures, and no patient required more than two balloon dilations to achieve sufficient urinary flow. In addition, no significant complications related to balloon dilation procedure such as ureteral perforation, urinary leakage or peri-ureteral hematoma were observed after each dilation procedures in every patient. The other 12 patients of the unsuccessful group, including the two patients who were unsuccessful with the second balloon dilation, underwent conservative therapy by chronic ureteral stent placement, where the stents were exchanged every 3 months. Moreover, no patient underwent either permanent metallic stent placement or endoureterotomy in this study.

According to logistic regression analyses performed for evaluation of the factors influencing successful balloon dilation (Table 5), stricture length >2 cm was a significant predictor of successful dilation in univariate analysis (odds ratio, 0.751; 95% confidence interval, 0.634-0.901; $p$-value, 0.030), yet failed to achieve an independent predictor status in multivariate analysis.

## DISCUSSION

### 1. Ureteral injury during gynecologic surgery and UUS

According to the previous studies concerning the complica-

tions of gynecologic surgery, the incidence rate of urinary tract injury ranges from 0.5 to 1.5% in which bladder is more vulnerable injury site compared to ureter [10,11]. For ureteral injury, the detection rate is 1.6 in 1,000 cases without performing intraoperative cystoscopy, but the rate increases up to 6.2 in 1,000 cases with the use of intraoperative cystoscopy so that the actual incidence rate of urinary tract injury might be higher if further investigated with long-term follow-ups [12]. In the present study, the incidence rate of ureteral injury due to gynecologic surgery was 0.1%, which was similar or slightly lower than that of previous studies. The relatively lower ureteral injury rate was probably attributable to the technical maturity of gynecologic surgeons at our institution. Ureteric injury, which is not found during the gynecologic surgery, may cause urinary obstructive signs including an increase in creatinine level and hydronephrosis depending on the site of ureteral injury. Moreover, infectious signs such as fever and flank pain can be also presented. According to Wu et al., some patients with gynecologic surgery experienced delayed ureteral necrosis and subsequent stricture owing to undiagnosed intraoperative thermal injury [13]. In this study, no patient presented delayed ureteral or bladder injury signs.

The location of ureteral injury is one of the major factors profoundly influencing the choice of surgical methods to repair the injury [14]. For the injuries of proximal ureter, UUS is a generally preferred method of surgical correction. UUS or UUS with a Boari flap can be a treatment option for mid ureter injury. UNC is a feasible treatment option for distal ureter injury if the remaining ureter maintains an adequate length [15,16]. However, if the length of remaining ureter after a resection of injured portion is insufficient, an ileal ureter substitution can be required [15-17]. In the present study, all 102 patients included in the final evaluation were diagnosed as ureteral injury immediately after the ureteral damage occurred, and this indicated the patients to undergo intraoperative UUS when the ureter was subjected to relatively less tissue inflammation compared to postoperative state. Thus, we believe that this immediate intraoperative UUS significantly reduced certain types of immediate to early postoperative complications such as urinary leakage or infection to the level of zero.

The overall ureteral stricture rate after intraoperative primary UUS was 92.1%, which was higher than the previous study results [17,18]. We believe this high ureteral stricture rate was derived from the patients' distinctive underlying pel-

vic anatomy. More than a half of the ureteral injury patients (50.3%) had a history of previous abdominopelvic surgery and more than two thirds of the ureteral injury patients (82.6%) accompanied severe adhesions of ureter with adjacent pelvic tissues. Moreover, 89 patients out of 155 ureteral injury patients were initially referred from other medical institutions for their gynecologic surgeries, because too highly technical gynecologic surgeries were required to the corresponding patients even at the operative planning stage. Thus, although the exact number of cases was not evaluated, a significant number of patients already had poor circulation and edema within the ureteral wall that were caused by extensive dissection of pelvic tissues undertaken before UUS procedure. These underlying conditions subsequently acted as potential technical difficulties to the urological surgeons involved in the study, which probably resulted in relatively poor outcomes after primary UUS.

## 2. Balloon dilation

The evaluation of outcomes in balloon dilation to the strictured ureter has been researched in many previous studies, yet, few of which analyzed the clinical outcomes of balloon dilation as a treatment of ureteral stricture occurring after UUS. To the best of our knowledge, this approach of particular note is the first study evaluating the therapeutic effect of balloon dilation to ureteral stricture after UUS, which was performed due to ureteric injury following gynecologic surgery. Bhayani et al. performed balloon dilation to four patients with strictured UUS and three of them (75%) showed successful outcomes [18]. Moreover, some of previous studies also pointed out profoundly successful outcomes of balloon dilation to strictured UUS in kidney transplantation (KT) patients with certain clinical factors [19-21]. Ooms et al. [21] demonstrated that the success rate of balloon dilation for a treatment of strictured UUS in KT patients was 47%, although they used both regular and cutting balloons for dilation procedure. In the present study, the success rate of initial balloon dilation was 60.8%, which was similar to the results of the previously published KT-patient based studies. In addition, most of the previous studies recommended performing balloon dilation for stricture length <3 cm, but the univariate analysis results of our study showed that stricture length >2 cm significantly decreased the success rate of balloon dilation. Our study results also demonstrated that inflating the balloon at the pres-

sure of 12 atm over 5 minutes is strongly recommendable as no post-dilation complication such as ureteral rupture was observed. According to Ambani et al. [22], they placed a ureteral stent in strictured ureter and perform a staged balloon dilation that resulted in 95% success rate. However, ureteral stent insertion prior to balloon dilation was not associated with successful outcomes of balloon dilation in this study. In addition, our study results showed the second balloon dilation, which was performed to the patients with initial balloon dilation failure, resolved ureteral stricture by 91.7% (22 successes out of 24 patients). Therefore, we believe the effect of staged balloon dilation should be analyzed in the further study with a larger study cohort.

This study has several limitations, and relatively small cohort size is one of them. Therefore, the clinical factors that could influence the success of balloon dilation might not have been included in the evaluation or no factor might actually influence the procedure success rate. Moreover, in this study, cutting balloons for dilation were not used, thus employing other types of balloons would possibly cause better outcomes. Although this study focused on the patients having ureteral stricture after UUS, UNC is performed as frequent as UUS for the treatment of ureteral injury caused by gynecologic surgery. Thus further studies including both UUS and UNC cases need to be undertaken to establish the treatment protocols for ureteral injuries after gynecologic surgeries. In general, the ureteral double J stent was indwelled for 12 weeks after balloon dilation in all study cohorts, but varying maintenance period might have resulted in different clinical outcome. Consequently, these factors should be taken into analysis in further study. Despite these limitations, we believe the present study still has the highest number of balloon dilations performed for strictured UUS in post-gynecologic surgery patients.

Balloon dilation is an effective treatment option for the strictured UUS in post-gynecologic surgery patients. The success rate of balloon dilation is 60.8%, and given the follow-up periods, no significant dilation related complications are observed. Stricture length <2 cm might be regarded as the key factor for a successful procedure. No other remarkable factors influencing the success rate of balloon dilation are noted, but it should be further investigated in future studies.

## CONFLICT OF INTEREST

The authors have no conflict of interest with any institu-

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