

## Urodynamic and urethral pressure profilometry findings in women with voiding phase dysfunction treated with surgical urethrolysis

Amy D. Dobberfuhr<sup>1</sup>, Craig V. Comiter<sup>1</sup>, Sayantan Deb<sup>2</sup>

<sup>1</sup>Department of Urology, Stanford University School of Medicine, Palo Alto, CA, United States; <sup>2</sup>Massachusetts General Hospital, Boston, MA, United States

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### ABSTRACT

**INTRODUCTION:** Long-term urodynamic (UDS) and urethral pressure profilometry (UPP) parameters in women with voiding phase dysfunction following an anti-incontinence (AI) procedure have been poorly characterized. We report our 10-year UDS findings in women with voiding phase dysfunction after AI procedure, who underwent urethrolysis.

**METHODS:** We identified sequential records containing urethrolysis current procedural terminology codes over a 10-year period. Records of women with preoperative UDS were reviewed for demographics, UDS tracing, and outcomes following urethrolysis.

**RESULTS:** Twenty-five women (mean age 60 years) had voiding phase dysfunction and underwent urethrolysis at a mean of 47 months (interquartile range [IQR] 12–61) after AI procedure. Preoperatively, six (24%) women required intermittent catheterization. Free uroflowmetry revealed a mean maximum peak flow (Q<sub>max</sub>) of 9.6 ml/s (IQR 7.0–11.0), voided volume of 137 ml (IQR 81–169), and postvoid residual of 167 ml (IQR 43–288). UDS revealed a mean UPP length of 24 mm (IQR 20–27), UPP closure pressure of 78 cmH<sub>2</sub>O (IQR 59–103), detrusor pressure at maximum flow (P<sub>det@Q<sub>max</sub></sub>) of 31 cmH<sub>2</sub>O (IQR 19–43), Q<sub>max</sub> of 7.9 ml/s (IQR 5.0–12.0), bladder outlet obstruction index of 15 (IQR 0–34), and bladder contractility index of 71 (IQR 60–81). UPP length was significantly associated (Pearson correlation,  $p < 0.05$ ) with bladder outlet obstruction index ( $r = 0.80$ ), P<sub>det@Q<sub>max</sub></sub> ( $r = 0.75$ ), and time since AI procedure ( $r = -0.70$ ). UPP closure pressure was significantly associated with age ( $r = -0.64$ ), volume of first ( $r = -0.64$ ) and strong ( $r = -0.78$ ) desire, and capacity ( $r = -0.71$ ). Following urethrolysis, spontaneous voiding was achieved in 23 (92%) women at followup (mean 308 days).

**CONCLUSIONS:** UPP may help characterize outlet parameters in women with voiding phase dysfunction following an AI procedure, who ultimately undergo urethrolysis.

### INTRODUCTION

The American Urologic Association (AUA) and Society of Urodynamics Female Pelvic Medicine & Urogenital Reconstruction (SUFU) guidelines exist for the surgical treatment of female stress urinary incontinence (SUI).<sup>1</sup> These include bladder neck suspension (retropubic and transvaginal), and bladder neck and midurethral slings. Although the mechanism underlying voiding phase dysfunction following these anti-incontinence (AI) procedures is not completely understood, excessive scar formation and misplacement of suspension sutures or the sling have been attributed to causing compression of the urethra and kinking of the bladder outlet.<sup>2,3</sup> The American Urogynecologic Society Committee on Gynecologic Practice has stated in their recommendations that, “Short-term voiding dysfunction after placement of a synthetic midurethral sling is common and, if improving, can be managed expectantly for up to six weeks; however, retention (inability to empty the bladder) or small-volume voids with large postvoid bladder residual volume should receive earlier intervention.”<sup>4</sup> While this guidance is helpful for acute voiding phase dysfunction, there limited guidance for women with long-term voiding phase dysfunction, although urethrolysis has become one of the mainstay treatments. The urethrolysis procedure can be performed in a retropubic, transvaginal, or suprameatal fashion, with or without a

## KEY MESSAGES

- We report 10-year UDS findings in women with voiding phase dysfunction following an anti-incontinence (AI) procedure, who underwent urethrolysis.
- UPP length was significantly associated with BOO index, Pdet@Qmax, and time since AI procedure.
- UPP closure pressure was significantly associated with age, volume of first and strong desire, and capacity.
- UPP may help characterize outlet parameters in women with voiding phase dysfunction following an AI procedure, who ultimately undergo urethrolysis.

Martius flap, to decrease further scarring. Resuspension can be attempted at the time of urethrolysis surgery, although this is controversial. Studies have reported resolution of SUI in 70–80% of patients following urethrolysis, with similar rates of SUI regardless of resuspension.<sup>5-7</sup> In up to 20% of patients, recurrent SUI can occur, and is often treated with bulking agent injection.<sup>8</sup>

Per the AUA/SUFU guidelines, urodynamics (UDS) may be obtained in the complicated patient when “invasive, potentially morbid, or irreversible treatments are considered,”<sup>9</sup> and as such, UDS have the potential to guide clinical decision-making in complex cases and improve surgical outcomes in the setting of storage and voiding symptoms related to outlet fibrosis, stress incontinence,<sup>10</sup> the large-capacity bladder,<sup>11</sup> outlet obstruction,<sup>12</sup> and detrusor underactivity.<sup>13</sup> Given the small number of women who undergo urethrolysis, UDS parameters prior to urethrolysis have not been sufficiently reported in the literature.

Urethral pressure profilometry (UPP) may be performed at the time of UDS by withdrawing the pressure profilometry catheter through the urethra, typically at a rate of 1 mm/s; by measuring the shape of the UPP, the length and maximum urethral closure pressure (MUCP) can be calculated. The utility of UPP in the urodynamic evaluation of women has been controversial.<sup>14,15</sup> Previous studies have reported the correlation of UPP parameters and incontinence symptoms.<sup>15,16</sup> MUCP has been noted to be higher in continent than

incontinent women. Likewise, low MUCP has been associated with SUI. Urethral length and MUCP have been found to be reproducible in SUI, but more variable in patients with detrusor overactivity. Furthermore, weak correlation has been shown between UPP and bladder neck mobility.<sup>17</sup> There are currently no studies that have reported the use of UPP in women prior to undergoing urethrolysis.<sup>18</sup> The aim of our study was to describe urodynamic and UPP findings, as well as surgical outcomes in women undergoing urethrolysis at our institution over a 10-year period.

## METHODS

After obtaining institutional review board study protocol approval, we identified sequential patient records, which contained urethrolysis current procedural terminology (CPT) codes at our institution from the years 2005–2015. We then identified records from this group with possible preoperative UDS CPT codes. A case-by-case retrospective chart review of each medical record was then performed. Study data were collected and managed using Research Electronic Data Capture (REDCAP)<sup>19</sup> tools hosted at our university. Data were compiled in REDCAP and included demographics, prior AI procedure, preoperative voiding characteristics, UDS parameters, urethrolysis surgical details, and postoperative outcomes. Following chart review, there were 25 women identified who had voiding phase dysfunction with complete charts and preoperative UDS followed by urethrolysis surgery.

Demographics of clinically obstructed women included body mass index (BMI), pelvic organ prolapse quantification staging vaginal exam (POP-Q), and preoperative medications. Prior AI procedures were descriptively characterized for each patient, along with time since procedure. Preoperative storage and voiding symptoms were characterized. Urodynamic tracings were directly reviewed and validated with the reported values from the urodynamic report. Urethrolysis operative notes were directly reviewed for intraoperative technical parameters, estimated blood loss, and presence of indwelling catheter at discharge. On followup, all 25 patients had followup data available for analysis, which included time since urethrolysis surgery at longest followup, ability to spontaneously void, the presence and nature of urinary incontinence, and any additional treatments for overactive bladder. Data were analyzed and are presented for mean, standard deviation (SD), interquartile range (IQR), and Pearson correlation coefficient. A p-value <0.05 was defined as significant.

### RESULTS

Twenty-five women underwent preoperative UDS and were treated with urethrolisis for the voiding phase dysfunction indication at our institution from 2005–2015. The mean age of the patients was 60 years at the time of urethrolisis (Table 1). Mean BMI of patients was 28. There was minimal prolapse present on POP-Q vaginal exam, whereupon 56% of patients had no anterior prolapse, 88% had no apical prolapse, and 72% had no posterior prolapse. In women with prolapse, it is our standard practice to reduce prolapse with a pessary to determine if there is a resolution of voiding phase dysfunction. Preoperatively, 44% of patients were prescribed bladder medications, with 32% using anticholinergics and 12% using alpha-blockers.

Prior AI procedure was performed at an average of 47 months (IQR 12–61) prior to urethrolisis (Table 1). The most common prior AI procedure was midurethral sling (68%). Native tissue procedures, such as Burch and Marshall-Marchetti-Krantz, comprised 28% of prior AI procedures. Descriptive categories for prior AI procedures were not mutually exclusive.

Preoperatively, urgency incontinence (56%) was the most common lower urinary tract symptom prior to surgery (Table 2). The second most common presenting symptom was sensation of incomplete emptying (40%). Most patients (76%) were voiding spontaneously before surgery, while the remaining (24%) required intermittent catheterization prior to urethrolisis.

In patients who were voiding spontaneously, free uroflowmetry prior to pressure flow UDS demonstrated a mean maximum peak flow (Qmax) of 9.6 ml/s (IQR 7.0–11.0), void volume of 137 ml (IQR 81–169), voiding time of 49 seconds (IQR 18–64), and postvoid residual (PVR) of 167 ml (IQR 43–288). In women with prolapse, it is our practice to reduce prolapse at time of urodynamics in order to standardize urodynamic assessment of the bladder and outlet. Complete preoperative UDS tracings were available on all 25 women for analysis. All women were able to void during the voiding phase of UDS testing, with a mean detrusor pressure at maximum flow (Pdet@Qmax) of 31 cmH<sub>2</sub>O (IQR 19–43) and Qmax of 7.9 ml/s (IQR 5.0–12.0) (Table 2). Valsalva voiding was demonstrated in 36% of women prior to urethrolisis. Mean UDS PVR was 211 ml (IQR 50–315). The calculated bladder outlet obstruction index (BOOI) for patients was 15 (IQR 0–34) and bladder contractility index (BCI) was 71 (IQR 60–81).

UPP was performed in all women (Table 2). This revealed a mean urethral length of 24 mm (IQR 20–27)

**Table 1. Preoperative clinical and surgical characteristics (N=25)**

Age on date of urethrolisis, years (mean ± SD, IQR)	60±14 (54–68)
Body mass index (mean ± SD, IQR)	28±5 (24–31)
<b>Anterior prolapse (n, %)</b>	
None	14 (56%)
Stage 1	6 (24%)
Stage 2	5 (20%)
Stage 3+	–
<b>Apical prolapse (n, %)</b>	
None	22 (88%)
Stage 1	3 (12%)
Stage 2	–
Stage 3+	–
<b>Posterior prolapse (n, %)</b>	
None	18 (72%)
Stage 1	4 (16%)
Stage 2	2 (8%)
Stage 3+	1 (4%)
<b>Preoperative bladder medication (n, %)</b>	
None	14 (56%)
Anticholinergic	8 (32%)
Alpha-blocker	3 (12%)
Time since prior AI procedure, months (mean ± SD, IQR)	47±49 (12–61)
<b>Prior AI procedure characteristics (n, %)</b>	
Mid-urethral sling	17 (68%)
Synthetic sling	15 (60%)
Retropubic sling	9 (36%)
Native tissue repair (Burch, MMK)	7 (28%)
Transobturator sling	4 (16%)
Bladder neck sling	2 (8%)
Biologic sling	2 (8%)
Autologous sling	1 (4%)

AI: anti-incontinence procedure; IQR: interquartile range; MMK: Marshall-Marchetti-Krantz; SD standard deviation.

and MUCP of 78 cmH<sub>2</sub>O (IQR 59–103). The association between UPP parameters (length, MUCP) and continuous variables were tested with Pearson correlation coefficient. UPP length was found to positively

**Table 2. Preoperative voiding and UDS characteristics (N=25)**

<b>Symptoms (n, %)</b>	
Urgency incontinence	14 (56%)
Sensation of incomplete emptying	10 (40%)
Stress incontinence	7 (28%)
Hesitancy	3 (12%)
Weak stream	2 (8%)
Mesh pain	1 (4%)
<b>Preoperative voiding status (n, %)</b>	
Spontaneous void	19 (76%)
Intermittent catheterization	6 (24%)
Indwelling Foley	–
<b>Free uroflowmetry (mean ± SD, IQR)</b>	
Qmax (ml/s)	9.6±4.2 (IQR 7.0–11.0)
Voided volume (ml)	137±74 (IQR 81–169)
Void time (s)	49±50 (IQR 18–64)
PVR (ml)	167±175 (IQR 43–288)
<b>Urethral pressure profile (mean ± SD, IQR)</b>	
Length (mm)	24±7 (IQR 20–27)
MUCP (cmH <sub>2</sub> O)	78±27 (IQR 59–103)
<b>Filling phase (mean ± SD, IQR)</b>	
First desire (ml)	218±168 (IQR 94–286)
Strong desire (ml)	314±202 (IQR 192–388)
Capacity (ml)	402±181 (IQR 268–495)
Detrusor overactivity (n, %)	12 (48%)
Stress incontinence (n, %)	5 (20%)
<b>Voiding phase (mean ± SD, IQR)</b>	
Pdet@Qmax (cmH <sub>2</sub> O)	31±18 (IQR 19–43)
Qmax (ml/s)	7.9±4.6 (IQR 5.0–12.0)
Valsalva voiding (n, %)	9 (36%)
PVR (ml)	211±182 (IQR 50–315)
<b>Calculated indices (mean ± SD, IQR)</b>	
BOOI (Pdet@Qmax - 2*Qmax)	15±20 (IQR 0–34)
BCI (Pdet@Qmax + 5*Qmax)	71±30 (IQR 60–81)

BCI: bladder contractility index; BOOI: bladder outlet obstruction index; IQR: interquartile range; MUCP: maximum urethral closure pressure; Pdet@Qmax: detrusor pressure at maximal flow; PVR: postvoid residual; Qmax: maximal flow, SD: standard deviation; UDS urodynamics.

correlate ( $p<0.05$ ) with increased BOOI ( $r=0.80$ ) and increased Pdet@Qmax ( $r=0.75$ ). UPP length was found to negatively correlate ( $p<0.05$ ) with time since AI procedure ( $r=-0.70$ ), such that women with the greatest UPP length had the shortest interval between their AI procedure and subsequent urethrolisis. MUCP was inversely associated ( $p<0.05$ ) with age ( $r=-0.64$ ), and as such, the highest urethral closure pressures for women undergoing urethrolisis were noted in the youngest women, and likewise older women sought urethrolisis for lower MUCP. With respect to UDS filling volumes, MUCP was inversely associated ( $p<0.05$ ) with volume of first ( $r=-0.64$ ) and strong ( $r=-0.78$ ) desire, as well as capacity ( $r=-0.71$ ), such that those women with the greatest closure pressures were found to have the lowest UDS infusion volume thresholds.

Urethrolisis was successfully performed in all women (Table 3), where 40% underwent partial sling excision, 32% simple sling incision, and only one complete excision, as previously described.<sup>20,21</sup> A 360-degree urethrolisis was performed in 48%, and 32% underwent infra-meatal urethrolisis. The mean estimated blood loss was 67 ml (IQR 20–100). The majority of women (80%) had an indwelling catheter placed at completion of urethrolisis, and 67% were discharged with a catheter. Most women (72%) were discharged on the day of surgery, while the remaining (28%) were discharged postoperative day 1.

The mean postoperative followup was 308 days (Table 3). Spontaneous voiding improved in most women, with 92% ultimately able to void spontaneously, up from 76% prior to surgery. Two patients continued to require intermittent catheterization at longest followup. Postoperatively, the most common bothersome symptom was urgency urinary incontinence in 36% of women, which improved from 56% prior to surgery. Three patients had mixed urgency predominant incontinence, and only two reported stress incontinence after surgery. Many patients (48%) did not require any additional pharmacologic or interventional treatment after surgery. Those requiring additional treatment were treated with anticholinergics (28%), alpha-blockers (12%), intradetrusor botulinum toxin A (4%), sacral neuromodulation (4%), and bladder augmentation (4%).

## DISCUSSION

Our retrospective study found that UPP correlated with several clinical and urodynamic parameters. We found that UPP length was significantly associated with BOOI, Pdet@Qmax, and time since AI procedure. UPP

**Table 3. Urethrolisis procedure and postoperative outcomes (N=25)**

<b>Urethrolisis technique (n, %)</b>	
360-degree urethrolisis	12 (48%)
Partial sling excision	10 (40%)
Sling incision	8 (32%)
Infra-meatal urethrolisis	8 (32%)
Complete excision	1 (4%)
<b>Surgical parameters (mean ± SD, IQR)</b>	
Estimated blood loss (ml)	67±75 (20–100)
Foley at completion (n, %)	20 (80%)
<b>Postoperative recovery (n, %)</b>	
Discharge from PACU	18 (72%)
Discharge POD 1	7 (28%)
Foley at discharge	17 (68%)
Longest followup, days (mean ± SD, IQR)	308±378 (45–461)
<b>Postoperative voiding status (n, %)</b>	
Spontaneous void	23 (92%)
Intermittent catheterization	2 (8%)
Indwelling Foley	–
Postoperative PVR, ml (mean ± SD, IQR)	68±82 (4–88)
<b>Postoperative incontinence (n, %)</b>	
Urgency	9 (36%)
Mixed (urge > stress)	3 (12%)
Stress	2 (8%)
Unknown	1 (4%)
Mixed (stress > urge)	–
<b>Postoperative treatments (n, %)</b>	
None	12 (48%)
Anticholinergics	7 (28%)
Alpha-blockers	3 (12%)
Intradetrusor botulinum toxin A	1 (4%)
Sacral neuromodulation	1 (4%)
Bladder augment	1 (4%)
IQR: interquartile range; PACU: post-anesthesia care unit; POD: postoperative day; PVR: postvoid residual; SD: standard deviation.	

closure pressure was significantly associated with age, volume of first and strong desire, and capacity prior to urethrolisis. Of the 25 women who underwent UDS

followed by urethrolisis, lower urinary tract symptoms, the ability to spontaneously void, and PVR improved in the majority of women following surgery.

In our cohort, 68% of women had undergone prior midurethral sling, with the majority of these being retro-pubic synthetic slings. The majority (56%) of women presented with urgency urinary incontinence as their most bothersome symptoms, and 40% reported a sensation of incomplete emptying. At postoperative followup, 92% patients were able to spontaneously void with low PVR. Urinary symptoms also improved for many patients on postoperative followup.

Our study adds to the scant literature that exists regarding the utility of UDS in women undergoing urethrolisis and specifically, correlation of UPP with clinical and UDS parameters. For a condition where many women had resolution of their condition following urethrolisis, our study encompasses a relatively long duration of followup for women who had UDS prior to surgery. UDS tracings were directly reviewed, therefore validating the original UDS interpretation.

There are few studies that have evaluated the utility of UDS and UPP in women and their association with clinical symptoms following surgery. One study found that even though UDS is performed regularly in women with incontinence, it does not affect clinical management of the patients, including the decision to offer surgery.<sup>14</sup> Another study found there was an indirect relationship between MUCP and incontinence. Similar to our study, this study found the MUCP decreased with age.<sup>15</sup> Increased age was associated with increased prevalence of mixed incontinence; however, this study did not find a direct correlation between urethral pressure profilometry and incontinence. Interestingly, in our study, MUCP was inversely associated ( $p < 0.05$ ) with age ( $r = -0.64$ ), and as such, the highest urethral closure pressures for women undergoing urethrolisis were noted in the youngest women, and likewise older women sought urethrolisis for lower MUCP. In considering the context of this finding, our patients were generally older, with a mean age of 60 years and relatively narrow age range (IQR 54–68). Based on our findings, there may be an association between bother, age, and outlet resistance, such that younger women are more likely able to tolerate a greater MUCP without bother, whereas older women may be more bothered at the same MUCP level, and as such, older women may seek urethrolisis at a lower MUCP threshold.

In patients undergoing urethrolisis, the UPP length provides valuable anatomic information that helps the surgeon determine which portion of the urethral profile

may benefit the most from urethrolisis. In support of this concept, we found that UPP length positively correlated ( $p < 0.05$ ) with increased BOOI ( $r = 0.80$ ) and increased Pdet@Qmax ( $r = 0.75$ ). Regarding MUCP, we feel that the value of the closure pressure may help the surgeon determine the amount of additional mobility needed to be gained by performing urethrolisis. In our opinion, UPP helps the surgeon performing urethrolisis, which traditionally would try to identify the point of resistance intraoperatively by passing a “Bougies a Boule” through the lumen of the urethra; however, when the patient is under anesthesia, resting urethral tone may be low as a result of anesthesia. In these cases, it is the actual shape of the profile, not just the MUCP alone, that may be the best indicator as to which portion of the urethra would benefit the most from the mobility gained through urethrolisis.

Following urethrolisis, we found that a subset of women report improvement of symptoms after surgery, especially the ability to spontaneously void, as reported by 92% of the women in our study, compared to 76% prior to surgery. Postoperatively, urgency incontinence, the most common bothersome symptom after surgery, improved to 36% after surgery, compared to 56% preoperatively. Our findings add to the literature, although there is a dearth of previously published studies. One case series reported improvement in retention and storage symptoms after surgery for 83% of the women studied, with improvement in PVR in all subjects.<sup>6</sup> Similarly another series found improvement in PVR in all subjects.<sup>22</sup> A larger cohort study found significant improvement in quality of life after urethrolisis, as well as improvement in PVR.<sup>23</sup> Another study, reported new overactive bladder symptoms in 21% of the patients who underwent urethrolisis.<sup>24</sup> Although a different endpoint than our study, taken collectively, these data show that urethrolisis can improve voiding phase dysfunction but, in some subjects, can result in new or persistent urgency.

With regards to the finding that UPP length negatively correlated ( $p < 0.05$ ) with time since AI procedure ( $r = -0.70$ ), while the IQR for length is relatively short, at 20–27 mm, further studies are needed to draw a direct conclusion with respect to UPP length and duration since AI procedure. Future studies may benefit from looking at not just the two rudimentary parameters of MUCP and length but studying the shape of the UPP curve in the context of flow dynamics through the flow control zone. UPP shape may be useful to understand the flow control dynamics of the female outlet and help classify various types of voiding dysfunction, such as bladder

neck obstruction, dysfunctional abdominal straining during voiding phase, pelvic floor dysfunction, outlet dysnergia, and other low- or high-flow situations.

We would encourage future studies that explore the utility of UPP and build upon the limitations of our study. In the context of our study, additional considerations include the lack of a comparison control group who underwent UPP but did not choose to undergo urethrolisis. Our study is a retrospective chart review reporting on UPP findings for a relatively uncommon surgical procedure. Prospectively collected data would control for recall and selection bias; however, given the relative rarity of urethrolisis and the 10-year time frame over which it took to identify the subjects in our present study, a prospective study would not be as efficient as a retrospective design. Future research into the utility of UDS to guide surgical decision-making could include repeating the UPP after surgery in order to assess change in UPP parameters, albeit this would need to be purely for scientific purposes since the standard of care does not necessitate a second UDS study after a successful urethrolisis procedure.

We found that almost all women with voiding phase dysfunction benefited for the outcome of spontaneous void following urethrolisis. The purpose of UDS is typically to exclude patients who may not benefit from a surgical intervention; as such, a future study would need to compare a group like ours against patients who underwent UDS and did not proceed to surgery. However, identification of a urodynamic subgroup who were considering urethrolisis but decided not to proceed with surgery would be challenging and would require a prospective study design to assess how decision-making was altered based on UDS findings. We expect that our findings will help fill the gap in knowledge for physicians seeking urodynamic and UPP reference comparator measures prior to urethrolisis.

## CONCLUSIONS

From our 10-year retrospective study of women with voiding phase dysfunction who underwent UDS prior to urethrolisis, we found that UPP length demonstrated the strongest correlation with elevated BOOI and Pdet@Qmax, consistent with an elevated degree of obstruction. Meanwhile lower MUCP was associated with older age, and women with the greatest closure pressures were found to have the lowest urodynamic infusion volume thresholds. Overall, UPP may help characterize outlet parameters in women with voiding phase dysfunction following an AI procedure, who ultimately undergo urethrolisis.

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CORRESPONDENCE: Dr. Amy D. Dobberfuhl, Department of Urology, Stanford University School of Medicine, Palo Alto, CA, United States; adobber@stanford.edu