Recovery of Voiding Efficiency and Bladder Function in Male Patients With Non-neurogenic Detrusor Underactivity After Transurethral Bladder Outlet Surgery

Kau-Han Lee and Hann-Chorng Kuo

OBJECTIVE The aim of this study is to investigate the treatment outcome in men with detrusor underactivity (DU) and voiding dysfunction who underwent transurethral resection or incision of the prostate (TURP or TUIP). DU usually affects decision making whether bladder outlet surgery is necessary.

MATERIALS AND METHODS A total of 60 men with urodynamic DU and voiding dysfunction who underwent TURP or TUIP from 1998 to 2015 were retrospectively analyzed for their treatment outcome after follow-up for more than 1 year. DU was defined as urodynamic evidence of low detrusor pressure (<40 cm H_2O), low flow rate (<10 mL/s), a postvoid residual urine volume >300 mL, and a voiding efficiency (VE) of <33%. Satisfactory outcome was defined as improved quality of life and having a VE of >50% after treatment. Predictive factor for a successful outcome was also analyzed.

RESULTS At a mean follow-up of 31 months, 49 (81.7%) patients had achieved a satisfactory treatment outcome. Among the patients who received TURP and TUIP, 38/44 (86.4%) and 11/16 (68.8%) had satisfactory outcome, respectively. The satisfactory group had significantly higher detrusor pressure and greater bladder compliance at baseline than the unsatisfactory group. There was significant improvement in the urodynamic parameters after treatment in the satisfactory group. Among the patients with satisfactory outcome, 34 (69.4%) patients had recovery of detrusor function within 3 months.

CONCLUSION Active surgical treatment such as TURP or TUIP results in recovery of VE and detrusor function within 3 months after treatment in the majority of patients with DU. UROLOGY 123: 235–241, 2019. © 2018 Elsevier Inc.

Detrusor underactivity (DU) is a common but poorly understood urologic problem. According to the terminology recommended by International Continence Society, DU is defined as a contraction of reduced strength and/or duration, resulting in prolonged bladder emptying, and/or failure to achieve complete bladder emptying within a normal time span.[1] Clinically, patients with DU usually have diminished bladder fullness or urgency sensation and cannot contract the detrusor sufficiently to complete bladder emptying.[2] Urodynamic findings in patients with DU include a normal or reduced bladder sensation, a low or acontractile detrusor pressure (Pdet), and poorly sustained detrusor contraction resulting in low maximum flow rate (Qmax) and large postvoid residual (PVR) urine volume.[3] The etiology of DU is thought to be multifactorial and has been shown to be linked to aging, bladder outlet obstruction (BOO), diabetes mellitus, neurological disorders, spinal cord lesions, and infectious neurologic diseases.[4] Health and quality of life may be compromised by DU and complications such as recurrent urinary tract infection (UTI) and renal function deterioration may occur if the condition is not properly treated.

The diagnosis of DU is frequently established in patients of advanced age, who present with lower urinary tract symptoms or urinary retention. Resnick et al reported that DU was found in nearly two-thirds of elderly persons with urinary incontinence.[5] The incidence and

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prevalence of DU are highly dependent on the definition and the availability of diagnostic tests. A retrospective study from South Korea showed that DU was diagnosed in 40.2% of men and 13.3% of women who underwent urodynamic study for lower urinary tract symptoms.[6] DU is also commonly seen in patients with general weakness and medical diseases such as diabetes mellitus, neurologic disease, and terminal stage cancer.[7] Diokno et al reported that in elderly men with difficult bladder emptying, pressure-flow study revealed underactive detrusor contractility in 28.2%, a mixed obstructive and underactive detrusor in 20.5%, and a normal pattern in 10.3% of participants.[8]

A long-term follow-up urodynamic study revealed that transurethral resection of the prostate (TURP) is not always effective in men with low detrusor contractility.[9] However, in our previous study we found that urethral botulinum toxin A injection resulted in relief of BOO and neuromodulation of the hypersensitive urethral sphincter and consequently restored detrusor function was postulated in patients with DU.[10] In clinical practice, we have noted that female patients with DU and chronic urinary retention may resume spontaneous voiding and normal detrusor contractility after appropriate treatment and bladder management with time.[11] Appropriate treatment in men with DU, however, is dependent on clinical and urodynamic findings and can include bladder outlet surgeries such as TURP and transurethral incision of prostate (TUIP). In this retrospective study, we analyzed the therapeutic outcome in male patients with voiding dysfunction, small to moderate prostate volume, and

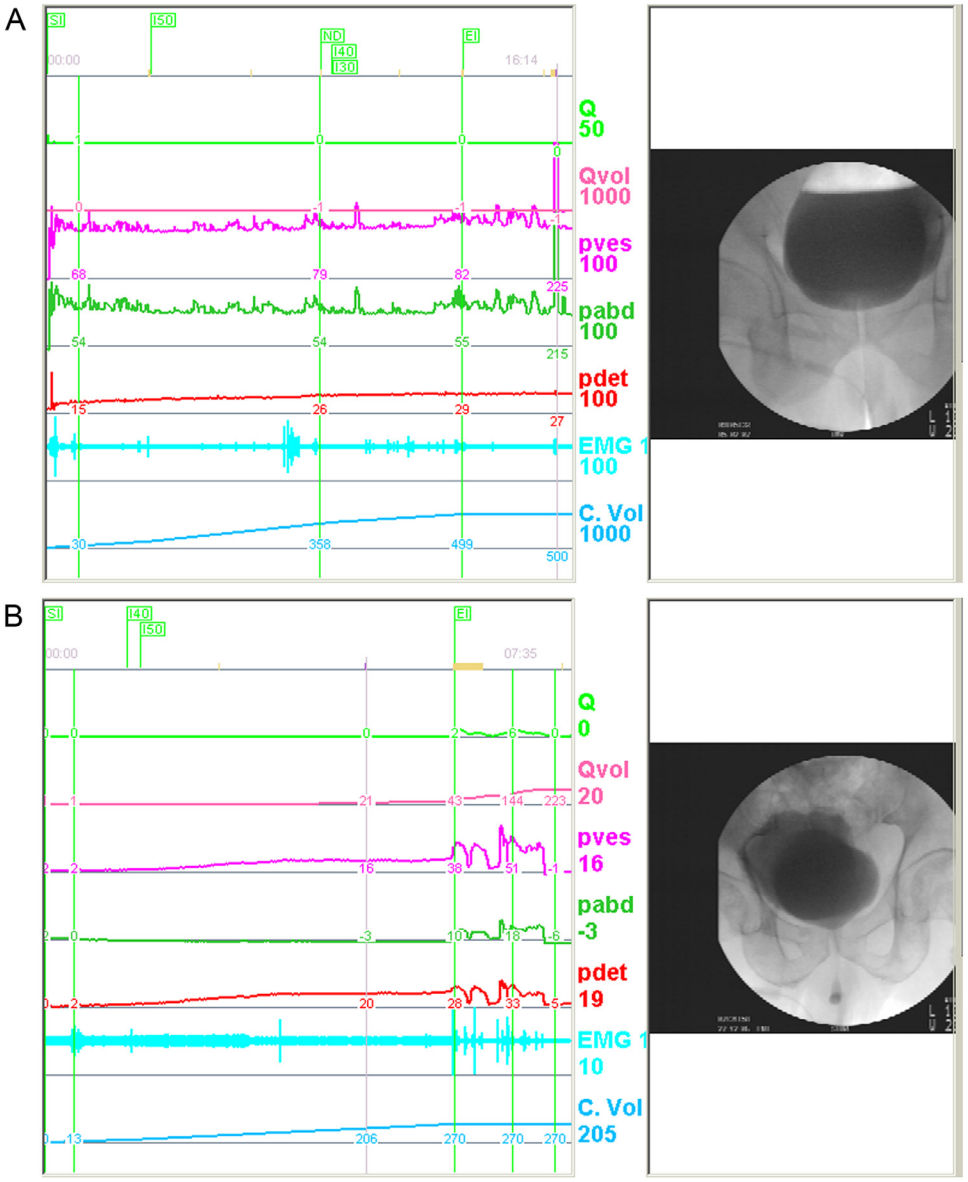

Figure 1. Videourodynamic study shows: (**A**) detrusor underactivity (DU) with high compliance and tight bladder neck, (**B**) DU with low compliance and open bladder neck and narrow urethral sphincter, (**C**) DU with tight bladder neck and high compliance at baseline, and (**D**) the same patient of (**C**) and improved detrusor function and open bladder outlet after transurethral incision of the prostate. (Color version available online).

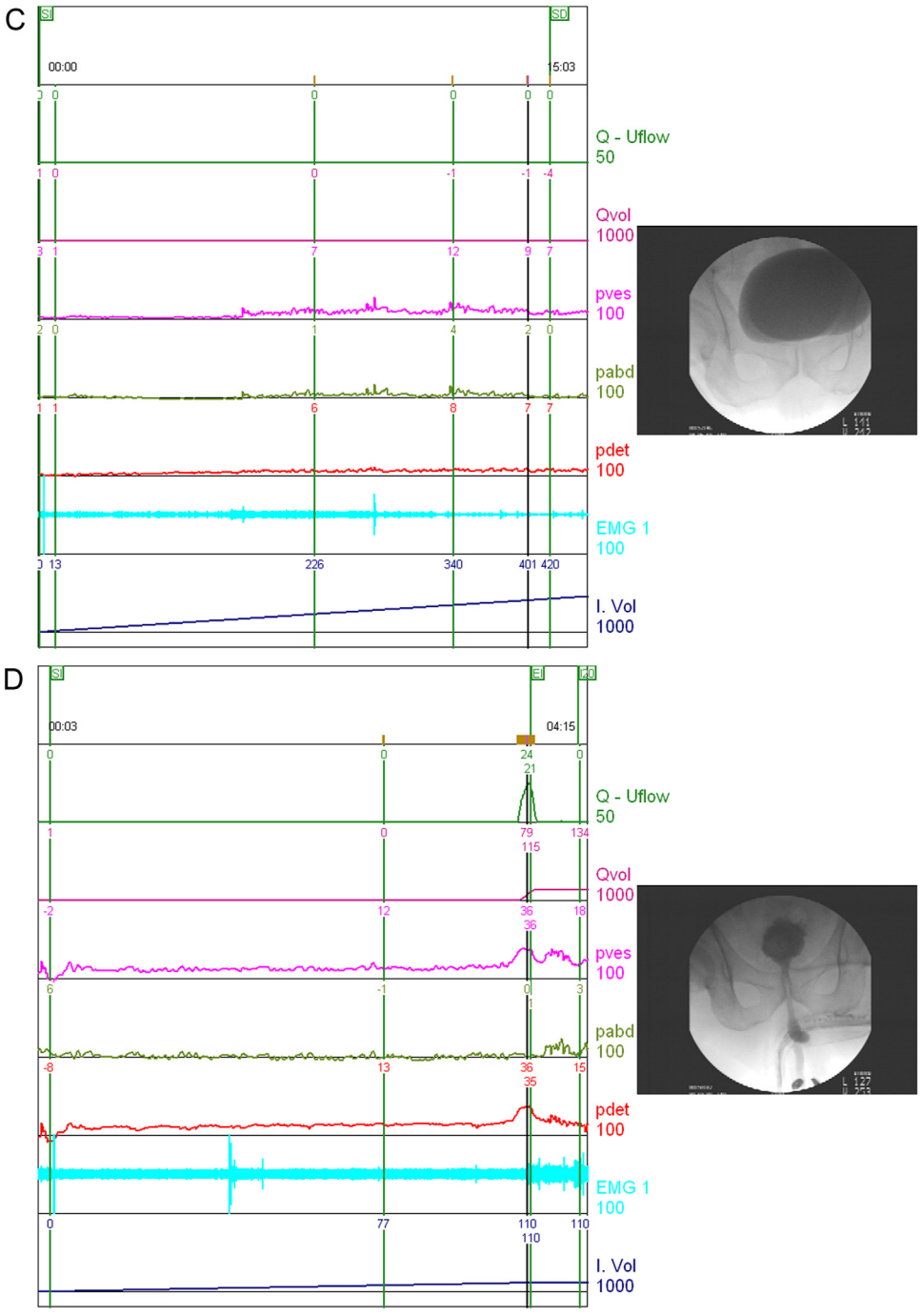

Figure 1 Continued.

urodynamically proven DU, and tried to identify whether any baseline urodynamic parameter can predict treatment outcome.

PATIENTS AND METHODS

We reviewed the medical records of all male patients who were treated for voiding dysfunction and having DU at our institute during the period January 1998-May 2015. All patients were noted to have urinary retention or having large PVR referred for further evaluation and management. All patients underwent videourodynamic studies (VUDS) prior to treatment. Patients with overt neurogenic lower urinary tract dysfunction, unable to ambulate, poor functional status, or total prostate volume (TPV) of more than 60 mL were not included in this study. This study was approved by the Ethics Committee of the institution (Buddhist Tzu Chi General Hospital IRB: 103-145-A) and informed consent was waived because this was a retrospective analysis.

In this study, DU was defined in patients with VUDS evidence of low detrusor voiding pressure (Pdet <40 cm H_2O), low Qmax (<10mL/s), a PVR >300 mL and a voiding efficiency (VE) <33%. VUDS was performed either in the standing position or a lying position in patients who could not stand. The

VUDS parameters were zeroed after all the catheters were inserted. VUDS was performed with a 6 Fr dual channel transurethral catheter to infuse and record intravesical pressure and an 8 Fr transrectal balloon catheter to record intra-abdominal pressure. The voiding Pdet was calculated by the Pdet at Qmax subtracting the end-filling Pdet. VE was calculated based on the urodynamic parameters. VE was calculated by the voided volume divided by the bladder capacity (voided volume plus PVR). In patients with indwelling catheter, the catheter was removed and VUDS was performed. Urethral sphincter activity was recorded using surface patch electromyography. A C-arm fluoroscope was used to monitor the filling and voiding phases throughout the examination. All urodynamic results were interpreted according to International Continence Society guidelines. The urodynamic parameters collected in this study included first sensation of filling, full sensation, urge sensation (US), compliance at bladder capacity, Qmax, Pdet at Qmax, voided volume, cystometric bladder capacity, PVR, and bladder contractility index.

Patients with VUDS proven DU and a nonopening bladder neck, and a TPV <30 mL received TUIP. Patients with DU and a TPV ≥30 mL underwent TURP.[12] In TUIP, the prostatic urethra was incised bilaterally at 5 and 7-o'clock position from the bladder neck to the level of verumontarum. The full thickness of the prostatic urethra was cut using a resectoscope without resection of the prostate tissue. Patients who did not resume spontaneous voiding or had a large PVR of >250 mL after prostatic surgery were managed with voiding training by a trocar cystostomy or were taught to perform clean intermittent catheterization (CIC). During bladder management, patients were instructed not to have PVR exceeding 350 mL during CIC or cystostomy training to avoid bladder overdistention. All patients were regularly followed up at the urologic clinic until they resumed efficient voiding. Satisfactory outcome was defined as having aVE (VE = voided volume/total bladder capacity) exceeding 50% after treatment. In patients who resumed spontaneous voiding, repeat VUDS was performed to confirm recovery of detrusor contractility. Figure 1 shows the VUDS images of patients with DU and the changes of detrusor contractility before and after treatment. We performed TUIP on this patient and after the treatment, the patient could void spontaneously.

STATISTICAL ANALYSIS

Continuous variables are represented as means ± standard deviations, and categorical data are represented by number and percentage (%). Differences between the groups were tested using the chi-square test for categorical variables and the Wilcoxon rank-sum test for continuous variables. A P value <.05 was considered to indicate statistical significance. All statistical analyses were performed using the statistical package SPSS (Version 15.0, SPSS Inc., Chicago, IL).

RESULTS

The study comprised 60 men ranging in age 44-90 years (mean 73 years). Of them, 30 (50%) had detrusor acontractile and acute or chronic urinary retention with an indwelling Foley catheter, and 30 (50%) had a large PVR volume but could void by abdominal straining. All patients were referred for evaluation and further management. The symptom of voiding dysfunction lasted 1 month-3 years. Of these 60 patients with DU, 49 (81.7%) had a satisfactory outcome. Satisfactory outcome was achieved in 38 (86.4%) out of 44 patients who received TURP and 11 (68.8%) of 16 who received TUIP. There was no significant difference in age and comorbidities between patients who received TURP and TUIP. Complications related to the surgical procedures were postoperative bleeding needing transfusion in 2/44 (4.5%) and 0/16, postoperative UTI in 8/44 (18.0%) and 2/16 (12.5%), and urethral stricture in 4/44 (9.0%) and 0/16, in patients received TURP and TUIP, respectively.

Patient characteristics, comorbidities, and VUDS parameters are shown in Table 1. There was no significant difference in age, hypertension, diabetes mellitus, coronary artery disease, or old stroke between the satisfactory and the unsatisfactory group. The TPV was greater in satisfactory group than unsatisfactory group (38.8 ± 25.1 vs 29.0 ± 9.34 mL, P = .078), but did not reach a significant difference. Patients with satisfactory outcome had significantly greater bladder compliance (79.1 ± 108.8 vs 38.3 ± 51.5 cm H_2O, P = .024) and higher Pdet (6.44 ± 7.59 vs 3.65 ± 3.30 cm H_2O, P = .02) than the other group. There was no significant difference in other baseline urodynamic parameters between the 2 groups (Table 1).

Satisfactory outcome was achieved within 3 months after treatment in 34 (69.4%) patients in the satisfactory treatment group. Satisfactory outcome in the remaining patients (n = 15, 30.6%) was achieved more than 3 months after treatment, with the longest time to recovery being 12 months.

Forty-six patients underwent follow-up VUDS at 3-6 months after treatment. Of them, 35 patients had satisfactory outcome. The follow-up VUDS showed significant improvement in first sensation of filling, full sensation, US, Pdet, Qmax, voided volume, PVR, cystometric bladder capacity, and bladder contractility index after treatment. In contrast, the unsatisfactory group had fewer significant improvements after treatment (Table 2). Among the 35 patients with satisfactory outcome, 30 (85.7%) had increase and 5 (14.3%) had no change in Pdet after TURP or TUIP. Among the 11 patients with an unsatisfactory outcome, 3 (27.3%) had Pdet increase and 8 (72.7%) showed no change in Pdet after surgery.

DISCUSSION

The results of this study revealed that active surgical treatment such as TURP and TUIP for male patients with DU and small to moderate TPV resulted in recovery of voiding function in 49 (81.7%) patients within 12 months after treatment. However, 11 (18.3%) patients remained on chronic urinary retention. In addition, we found that larger bladder compliance and a higher baseline Pdet are associated with a satisfactory outcome.

The goal of treatment for DU is to resume spontaneous voiding, reduce PVR, prevent UTI, and renal function

Table 1. Demographics and videourodynamic parameters in patients with detrusor underactivity

	Satisfactory (N = 49, 81.7%)	Unsatisfactory (N = 11, 18.3%)	*P* value
Age	72.97 ± 9.78	71.7 ± 10.62	.603
Hypertension	34 (54.0%)	12 (52.2%)	.882
Diabetes	18 (28.6%)	7 (30.4%)	.582
CAD	14 (22.2%)	5 (21.7%)	.962
Old stroke	10 (15.9%)	5 (21.7%)	.526
TURP	38 (86.4%)	6 (13.6%)	.005
TUIP	11 (68.8%)	5 (31.2%)	.652
TPV (mL)	38.8 ± 25.1	29.0 ± 9.34	.078
FSF (mL)	216.6 ± 115.3	199.4 ± 112.8	.54
FS (mL)	321.7 ± 126.9	302.3 ± 154.5	.753
US (mL)	371.2 ± 137.3	354.8 ± 170.2	.659
Compliance	79.1 ± 108.8	38.3 ± 51.5	.024
Pdet (cmH_2O)	6.44 ± 7.59	3.65 ± 3.30	.020
Qmax (mL/s)	1.98 ± 3.17	1.39 ± 2.95	.437
Volume (mL)	51.2 ± 92.2	26.9 ± 48.4	.234
PVR (mL)	353.6 ± 206.0	402.4 ± 165.9	.311
CBC (mL)	404.8 ± 182.5	429.3 ± 142.0	.562
BCI	16.4 ± 19.8	10.6 ± 15.1	.209

BCI, bladder contractility index; CAD, coronary artery disease; CBC, cystometric bladder capacity; FS, Full sensation; FSF, first sensation of bladder filling; Pdet, detrusor voiding pressure; PVR, post-void residual; Qmax, maximum urinary flow rate; TPV, total prostate volume; TUIP, transurethral incision of prostate; TURP, Transurethral resection of prostate; US, urgency sensation; VOL, voided volume.

Table 2. Changes in the urodynamic parameters of patients with detrusor underactivity after treatment

	Satisfactory (N = 35)		Unsatisfactory (N = 11)	
	Baseline	Post Tx	Baseline	Post Tx
FSF (mL)	206 ± 116	151 ± 107*	222 ± 131	149 ± 96.3
FS (mL)	300 ± 119	228.1 ± 138*	341 ± 174	222 ± 114
US (mL)	364 ± 139	260 ± 172*	419 ± 163	274 ± 141*
Compliance	82.0 ± 116	44.2 ± 53.4	46.3± 46.7	26.8 ± 26.4
Pdet.Qmax (cm H_2O)	7.26 ± 8.45	28.6 ± 29.1*	3.36 ± 3.04	10.1 ± 10.4
Qmax (mL/s)	2.33 ± 3.42	6.47 ± 7.93*	0.09 ± 0.30	1.45 ± 2.02
Voided volume (mL)	60.3 ± 98.4	143 ± 175 *	4.54 ± 15.1	50.4 ± 99.3
PVR (mL)	334 ± 194	166 ± 168*	4723 ± 135	268 ± 145*
CBC (mL)	394 ± 173	309 ± 171*	477 ± 129	319 ± 124*
BCI	16.4 ± 19.8	61 ± 49.9*	10.6 ± 15.1	17.4 ± 20.1

* $P < .05$; comparison between the baseline parameters and parameters obtained after treatment using the paired *t* test.

deterioration. Treatment strategy includes medications to improve detrusor contractility or relieve BOO, surgical treatment to decrease bladder outlet resistance, and sacral neuromodulation to increase cortical perception of bladder sensation. Medications such as parasympathomimetics and alpha-blockers have been shown to have limited benefit and unfavorable side effects in treating DU.[13-15] Patients with DU can be managed with CIC, indwelling Foley catheter, or cystostomy; however, these bladder management techniques have a poor impact on quality of life. Therefore, active surgical treatment is usually advocated by urologists to a patient who presents with urinary retention with or without urodynamic demonstrating DU or low contractility.[16-18]

In this study, TUIP or TURP was performed in male patients with DU, large PVR, and small to moderate TPV. Although it is difficult to differentiate between BOO and nonobstruction in patients with DU even by video urodynamic study, this study revealed that over 80% of men with DU could regain spontaneous voiding after bladder outlet surgery. Although the other 14.3% of patients did not have recovery of detrusor function, they still could void spontaneously by abdominal straining to achieve a satisfactory VE. The surgery not only relieves bladder outlet resistance but also might destruct the inhibitory effect of the detrusor contractility caused by alpha-adrenergic hyperactivity in the bladder neck and prostatic urethra, thus facilitating urination in male patients with idiopathic DU, either by spontaneous voiding or abdominal straining.[19,20]

Since the bladder neck and prostatic urethra are innervated mainly by the sympathetic adrenergic nerves, ablation of the bladder neck, and prostatic urethra might abolish the sympathetic hyperactivity which inhibits detrusor contractility.[20] It is also possible that the inhibitory effect of adrenergic hyperactivity on detrusor contractility can be modulated after TUIP or TURP, resulting in a recovery of detrusor function. In our previous study we

found that Transurethral incision of bladder neck (TUI-BN) resulted in a decrease in bladder outlet resistance in female patients with DU.[21] Studies have also shown that patients with idiopathic DU who undergo TUI-BN can regain adequate detrusor contractility and resume spontaneous voiding.[11,21] Previously published papers using animal models have shown that the functional recovery after bladder outlet surgery might be due to the return of urinary bladder blood flow and cellular function of the detrusor muscle.[22] This phenomenon is observed not only in neurogenic DU but also in non-neurogenic DU,[10,23] suggesting that bladder outlet surgery might trigger micturition in DU bladders. A recent clinical study also showed that 80% of patients with an acontractile bladder achieved a return of detrusor contractility after laser enucleation of the prostate.[24]

In the present study, higher voiding Pdet and larger compliance were associated with satisfactory outcomes following bladder outlet surgery. As mentioned earlier, treatment that abolishes sympathetic hyperactivity might restore detrusor contractility. Smith et al reported that DU might be caused by diminished bladder sensitivity, resulting in premature termination of the micturition reflex.[2] In this study we found that restoration of detrusor function was more likely to occur in patients with a higher baseline voiding Pdet. A small difference in the mean Pdet between satisfactory and unsatisfactory groups might not have clinical significance. However, because most of the patients with urodynamic DU did not have a measurable Pdet, therefore, the higher mean Pdet in the patients with satisfactory outcome reflects a larger portion of patients having a measurable Pdet, which might also indicate the reserved detrusor contractility in these patients. This could explain that the detrusor function in these cases was not completely lost and had a better chance to regain efficient detrusor contractility compared to those with unsatisfactory outcomes. If the patients with DU have a measurable Pdet at the baseline, then active treatment should be provided as patient might have satisfactory outcome after the treatment as shown in this study.

In addition, higher bladder compliance at baseline implies that the bladder wall has less fibrotic change compared with the bladders with a low compliance. With a measurable detrusor voiding pressure and higher bladder compliance, patients with DU could have a better chance to regain spontaneous urination and better VE. DU might be a result of chronic bladder overdistention and prolong ischemia. In this study we instructed patients to keep a PVR <350 mL and avoid bladder overdistention. Appropriate bladder management either by CIC or cystostomy training is also important in detrusor function recovery.

Normal micturition requires normal bladder sensation and transduction of stretch (urothelial pathway). The sensory activation of the micturition reflex is essential for normal detrusor contractility on stimulation.[25] Clinical observation in patients who have acute or a chronic sensory afferent nerve lesion (such as herpes zoster infection or syphilis-induced tabes dorsalis), detrusor contractility is greatly impaired and urinary retention may ensue. Furthermore, a normal perception of bladder fullness and US is the fundamental basis for normal micturition. Patients with a severe cortical degenerative disease may lack bladder perception and may be unable to initiate voiding. Aging can cause structural and functional changes of the bladder afferent nerves and detrusor power, and might impair reflex activity.[26] In the present study, most patients with satisfactory outcome had significant increase of bladder sensation along with improvement of Pdet, further highlights the relationship between bladder sensation and detrusor function. In addition, chronic BOO and latent cortical degeneration resulting in DU might also occur in elderly patients, especially when they experience severe illness or major surgery. In this study, most patients with unsatisfactory outcome had debilitating disease that greatly affected detrusor contractility, making it difficult to recover even after treatment.

Although no significant difference was reached in TPV, the mean TPV was larger in the satisfactory group. Patients who had satisfactory results might have DU owing to chronic BOO, whereas DU in those who failed bladder outlet surgery might not associate with BOO. Nevertheless, about 30% of patients regained spontaneous voiding after 3 months, suggesting the recovery of detrusor contractility takes time, especially in those who have chronic urinary retention and debilitative systemic diseases. A longer time may be needed for the recovery in patients who failed surgical treatment within the first year. It is mandatory to avoid bladder injury in these patients due to repeat overdistention during voiding training.

Age is highly associated with DU. DU is present in 9%-28% of men <50 years of age increasing to as much as 48% in men >70 years.[27] Aging may directly cause diminished detrusor contractility or impaired afferent signaling.[26,28] DU is also common in older patients with general weakness and medical diseases.[7] In this study, the mean age was 73 years and many medical comorbidities are associated with DU, further emphasizes that age may affect the detrusor contractility. Recently, Suskind et al reported that 94% of male nursing home resident patients with poor baseline functional status, decline of function prior to surgery, higher number of hospitalization in the year prior to surgery, and having a Foley catheter preoperatively were associated with greater risk of TURP failure.[29] The study indicates that these frail patients with a poor baseline general condition and presence of a catheter might not benefit from BOO surgery. In present study, the mean age of DU patients was 73 years and we did not include patients with overt neuropathic voiding dysfunction, unable to ambulate, or poor functional status. With careful evaluation of patients with DU based on clinical and urodynamic findings, we have demonstrated that majority of male patients could have benefit from active treatment such as TURP or TUIP and improve their quality of life.

There are some limitations in the present study that need to be considered. First, this is a retrospective study with small sample size in a single center. Although overt

neurogenic bladder was excluded, some patients with occult neurologic disease might be inadvertently included. This may have caused selection bias in the patient population. In addition, the follow-up course was not well scheduled and was not comprehensive. Nevertheless, the high rate of satisfactory outcome suggests that surgical treatment of male patients with DU or chronic urinary retention can effectively improve VE and quality of life, even in cases where the prostate volume is less than 30 mL.

CONCLUSION

Active surgical treatment for DU such as TURP or TUIP results in recovery of VE and detrusor function within 12 months after treatment in 81.7% of patients. A higher voiding Pdet and larger bladder compliance may predict a satisfactory outcome.

AUTHOR CONTRIBUTIONS

Kuo Hann-Chorng contributed to the conception, design of the study and revising the manuscript critically for important intellectual content. Kau-Han Lee is responsible for the data acquisition, and drafting of the manuscript. All authors read and approved the final manuscript.

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