Predictive Urodynamic Parameters for The Treatment Efficacy of Onabotulinum Toxin A in Neurogenic Lower Urinary Tract Dysfunction

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Purpose: To evaluate urodynamic parameters that may serve as predictors of treatment efficacy with Onabotulinumtoxin-A (onaBoNT-A) in patients with neurogenic lower urinary tract dysfunction (NLUTD).

Materials and Methods: Patients with NLUTD who received 200 IU onaBont-A injections were included in the study. Urodynamic parameters and the correlations between these parameters and treatment outcomes were analyzed. The primary endpoints were changes in the daily pad usage, and the secondary endpoint was to demonstrate the relationship between duration of treatment efficacy of onabotulinumtoxin-A with preoperative urodynamic parameters in patients with NLUTD.

Results: The data of 74 patients were analyzed retrospectively, and 66 (89%) patients benefited from onaBoNT-A treatment. A negative correlation was observed between the number of pads changed per day and maximum cystometric capacity (MCC) (p = 0.024, r = -0.277). A positive correlation existed between the duration of treatment efficacy of onaBoNT-A and change in detrusor pressure during filling cystometry (ΔPdet) (p = 0.018, r = 0.291), whereas a negative correlation was noted with bladder compliance (p = 0.035, r = -0.260). Any additional indicator of its urodynamic efficacy showing a correlation with the number of pads changed per day has not been identified yet.

Conclusion: OnaBoNT-A injections effectively manage NLUTD, with MCC being a potential predictor of treatment response. Other urodynamic parameters showed limited predictive value. Patients with lower MCC experienced greater improvements in reducing the number of pads used following treatment. High ΔPdet and low bladder compliance were associated with treatment benefits persisting for longer periods of time.

Keywords: onabotulinumtoxin A; neurogenic lower urinary tract dysfunction; urodynamics

INTRODUCTION

Management of neurogenic lower urinary tract dysfunction (NLUTD) is a complex multifactorial process that requires a multidisciplinary approach. Inadequate management of NLUTD can lead to potentially serious and progressive outcomes such as renal failure due to upper urinary tract (UUT) damage. In addition, it can negatively affect quality of life[(1)]. The goal of clinical management in this patient population is to preserve UUT, achieve, and maintain urinary continence, and improve quality of life[(2)].

Antimuscarinics are the first-line treatment alternatives for neurogenic detrusor overactivity (NDOA) [(3)]. Onabotulinumtoxin- A (onaBoNT-A) injection is recommended as the next treatment option in cases of inadequate response or intolerance to conservative and pharmacological treatments[(4)]. The use of onaBoNT-A in the treatment of NDOA was first described in 2000 [(5)]. The effectiveness of onaBoNT-A has been reported to sustain for 3 to 12 months, with an average treatment benefit lasting approximately 6 months[(6)]. Numerous studies performed since the first description of this treatment modality by Schurc et al have demonstrated that the injection of onaBoNT-A can improve both urodynamic parameters and the quality of life of the patients[(7,8)].

In patients with neurogenic lower urinary tract dysfunction (NLUTD), urodynamic data are valuable for the implementation of optimal clinical management. Various studies have assessed treatment responses based on parameters, such as maximum cystometric capacity (MCC), change in detrusor pressure during filling cystometry (ΔPdet), and compliance[(9,10)]. Unlike many other studies, the present research has focused on assessing MCC, ΔPdet, and compliance, as well as urodynamic parameters, including vesical maximum pressure (pVesMax), NDOA, bladder volume at the first involuntary detrusor contraction (IDC), detrusor leak point pressure (DLPP), detrusor leak point volüme (DLPV), which could predict the success of onaBoNT-A therapy.

MATERIAL AND METHODS

Study participants

The study was approved by the ethics committee on September 20, 2023 (2023/239). Patients with NLUTD who were treated with 200 IU onaBoNT-A injections at a tertiary urology department between September 2013, and September 2023 were included in the study. In this retrospective study, patients with NLUTD aged >18 years, who did not respond adequately to antimuscarinics or could not tolerate their side effects despite treatment with at least two different antimuscarinic

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Table 1. Demographic and clinical data of the groups.

	Groups		
	Group 1 n=66	**Group 2 n=8**	***p***
Female n, (%)	36 (54.5)	4 (50.0)	0.808
Male n, (%)	30 (45.5)	4 (50.0)	
Age (year)	52.5 (36 - 72)	42 (37 - 49)	0.431
Number of the pads used per day (median) (min-max)			
preoperative	5 (4 -6)	6.5 (3.5-7.5)	0.244
postoperative	3 (1 -4)	6 (3.5-7)	0.005*
Duration of treatment efficacy of onaBoNT-A (months) / median (95% CI)	6 (5.42-7.04)	0 (-0.17-0.42)	0.001*
Presence of hydronephrosis n, (%)	8 (12.1)	0	0.297
CIC n, (%)	6 (9.09)	2 (25)	0.179

n: number of the patients,
CI: Confidence Interval
onaBoNT-A: Onabotulinumtoxin-A
* The level of statistical significance: $p < 0.05$; Mann-Whitney *U* test.
CIC: clean intermittent catheterization

agents for a minimum of 3 months, received 200 IU of onaBoNT-A injections for the first time, and followed up regularly for the duration of at least 12 months, were included. Patients with LUTD due to functional or non-neurogenic etiologies, those who received onaBoNT-A doses either other than 200 IU or its multiple doses, pediatric patients, incomplete data and no follow-up visits were excluded from the study.

Detailed medical history was obtained, and etiological factors leading to NLUTD, presence of urinary incontinence (UI), frequency of UI, voiding, the number of pads used per day and clean intermittent catheterization (CIC) were recorded. Urinalysis, urine culture, and biochemical blood tests were performed to assess the renal function. All patients with NLUTD underwent urinary tract ultrasonographic examinations to investigate the presence of hydronephrosis.

Urodynamic evaluation

Urodynamic tests were performed by two nurses (one man, one woman) who had experience in urodynamic examination. Almost all parameters were assessed by Dr. OB (Prof), who has been a specialist in ''Neurourology''. We performed filling cystometry and a standardized protocol was employed according to ''International Continence Society'' reports[11,12].

In the presence of a symptomatic urinary tract infection, appropriate antibiotic therapy was initiated based on urine culture results, and urodynamic studies were not performed. However, urodynamics (filling cystometry) were performed in patients with asymptomatic bacteriuria or negative urine culture results, and the following parameters were evaluated: MCC, ΔPdet, pVesMax, compliance, NDOA, IDC, DLPP, DLPV.

Surgical procedure

The procedure was performed under local, general or sedation anesthesia with the patient in the lithotomy position. Each 100 IU of onaBoNT-A (Botox®, ALLERGAN, Westport Co, Mayo, Ireland) was diluted with 10 ml saline. During rigid or flexible cystoscopy, 200 IU of onaBoNT-A was injected at a depth of 4 mm into the bladder wall at 20 different points approximately one centimeter apart[13]. In patients who were unable to mobilize, bladder catheterization was performed for the first 6-24 hours after the operation.

Follow-Up

The primary endpoints of the current study were changes in the daily pad usage in patients with NLUTD, who underwent onabotulinumtoxin-A injections. UI was assessed every 3 months (3rd, 6th, 9th, 12thmonths) during the postoperative period. In addition; we aimed to present the correlation between the decrease of pad

Table 2. Comparison of urodynamic parameters between groups

	Group 1 (n=66)	**Group 2 (n=8)**	***p***
MCC / ml	213 (128-296)	218 (129-361)	0.741
ΔPdet (cmH_2O), (median average)	52.5 (30 -66)	38 (25 -48.5)	0.098
pVesMax (cmH2O), (median average)	58 (41 -84)	43 (25 -63.5)	0.121
Bladder compliance (ml/cmH_2O), (median average)	3.95 (1.97-8.18)	7.16 (3.7-11.09)	0.156
Presence of DLPP (n), (%)	22 (33.3)	5 (62.5)	0.106
DLPP (cm H2O), (median average)	34 (22 -49)	16 (15 -45)	0.569
DLPV (ml), (median average)	140.5 (90-206)	157 (129-272)	0.237
Phasic NDOA (n), (%)	40 (60.6)	4 (50)	0.564
Terminal NDOA (n), (%)	55 (83.3)	6 (75)	0.559
IDC (ml), (median average)	75 (20 -140)	45 (20 -80)	0.534

ml: milliliter
n: number of patients
MCC: maximum cystometric capacity
Δ Pdet: change in detrusor pressure during filling cystometry
pVesMax: vesical maximum pressure
DLPP: detrusor leak point pressure
DLPV: detrusor leak point volüme
NDOA: neurogenic detrusor overactivity
IDC: bladder volume at the first involuntary detrusor contraction
* The level of statistical significance: p<0.05; chi-square test.

Table 3. Results of multiple regression analysis for subgroups of Group 1

		ΔPad Difference	MCC (ml)	IDC (ml)	pVesMax (cmH_2O)	ΔPdet (cmH_2O)	Compliance(ml/cmH_2O)	DLPV (ml)
Treatment efficacy of onaBoNT-A in months	r	0.270*	-0.130	-0.007	0.151	0.291*	-0.260*	0.035
	p	0.028	0.300	0.956	0.225	0.018	0.035	0.877
	n	66	66	60	66	66	66	22
Changes in the daily frequency of pad usage	r	1.000	-0.277*	0.075	-0.033	-0.073	-0.104	0.088
	p	.	0.024	0.567	0.793	0.559	0.404	0.697
	n	66	66	60	66	66	66	22

ml: milliliter
onaBoNT-A: Onabotulinumtoxin-A
ΔPad difference: changes in the daily frequency of pad usage between groups
MCC: maximum cystometric capacity
IDC: bladder volume at the first involuntary detrusor contraction
pVesMax: vesical maximum pressure
Δ Pdet: change in detrusor pressure during filling cystometry
DLPV: detrusor leak point volüme
* The level of statistical significance: $p < 0.05$, Spearman's correlation analysis

usage with preoperative urodynamic parameters. The time lapsed to return to the pad used levels before onaBoNT-A injections was recorded as the duration of the benefit. The secondary endpoint was to demonstrate the relationship between duration of treatment efficacy of onabotulinumtoxin-A with preoperative urodynamic parameters, in patients with NLUTD.

Patients who did and did not respond to the 200 IU onaBoNT-A injections were allocated to Groups 1, and 2, respectively. The responder group was categorised based on changes in patients' pad use per day (reduction in number of pads usage), reduction in voiding frequency, UI frequency and number of CICs after treatment compared to pre-treatment use. There was no change in these parameters in the non-responder group. The first assessment was made at 3 months post-operatively and followed up every 3 months. The duration of treatment efficacy was determined by the return to pre-treatment use levels.

This study was approved by the ethics committee of the University of Gaziantep (decision no:2023/239) and was performed in accordance with the ethical standards laid down in the 1964 WMA Declaration of Helsinki and its later amendments. All eligible participants signed an informed consent form.

Statistical Methods

The data were tested for normal distribution using the Shapiro-Wilk test. The Mann-Whitney U test was used for intergroup comparisons of non-normally distributed numerical variables, while the chi-square test was used for comparisons of categorical variables. Repeated measurements were evaluated using repeated-measures ANOVA. For the subgroup analysis, the Spearman statistical analysis method was employed to determine whether there was a correlation between the proportional momentum data of non-normally distributed independent variables. Assumptions were tested before Repeated Measures Anova Analysis. For the assumption of normality of the residuals, residuals were calculated and Q-Q lot was plotted. According to the result of variant homogeneity, variant homogeneity was provided with a probability of p values greater than 0.05. Finally, Mauchly's Sphericity Test was performed for the assumption of sphericity and according to the obtained results, the assumption of sphericity was provided. Linear regression analysis was used to evaluate the effect of categorical variables on the duration of benefit derived from onaBoNT-A injections and the change in the daily number of pads used. SPSS for Windows version 24 software was used for data analysis, and *p*-value < 0.05 was considered statistically significant.

Table 4. Results of the regression analysis of categorical variables impacting the duration of the treatment efficacy of onaBoNT-A and the number of pads used per day.

Duration of the treatment efficacy of onaBoNT-A					
	B	**Std**	**ß**	**t**	***p***
Gender 1.01	0.800	0.153	1.263	0.211	
Phasic NDOA	0.220	0.799	0.033	0.275	0.784
Terminal NDOA	-0.032	1.057	-0.004	-0.03	0.976
DLPP	-1.239	0.852	-0.178	-1.454	0.151
Hydronephrosis	-3.787	1.186	-0.377	-3.194	0.002*
The number of pads used per day					
	B	**Std**	**ß**	**t**	***p***
Gender	-0.260	0.318	-0.110	-0.818	0.417
Phasic NDOA	0.427	0.332	0.177	1.285	0.204
Terminal NDOA	-0.362	0.411	-0.114	-0.881	0.382
Presence of DLPP	0.079	0.372	0.031	0.211	0.834
DLPP	0.008	0.013	0.145	0.62	0.543
DLPV	-0.001	0.003	-0.50	-0.214	0.833
Hydronephrosis	-0.657	0.456	-0.182	-0.182	0.155

onaBoNT-A: Onabotulinumtoxin-A
NDOA: neurogenic detrusor overactivity
DLPP: detrusor leak point pressure
DLPV: detrusor leak point volüme
* The level of statistical significance: p<0.05

RESULTS

Demographic and clinical data

The data of 376 patients were analyzed retrospectively. Patients with LUTD due to functional or non-neurogenic etiologies (n = 135), those who received onaBoNT-A doses either other than 200 IU or its multiple doses (n = 59), pediatric patients (n = 61), incomplete data and no follow-up visits (n = 47) were excluded from the study. Consequently, 74 patients who met the inclusion criteria were evaluated. The patients who did (n: 66; 89%), and did not benefit (n:8;11%) from onaBoNT-A injections constituted Groups 1, and 2, respectively. Any statistically significant differences were not observed between the two groups in terms of age and sex distribution (p = 0.431 and p = 0.808, respectively) (**Table 1**). Mild and higher-grade hydronephrosis was detected in 8 (12.1%) patients.

Upon evaluation of the total patient population in terms of etiopathogenesis, spinal cord injury (SCI) emerged as the most prevalent factor (n = 20, 27%). Additional etiological factors included pelvic surgery (n=15, 20.2%), diabetes mellitus (n = 10, 13.5%), suprapontine lesions [(such as head trauma, cerebrovascular accident, hydrocephalus, epilepsy (n = 10, 13.5%)], lumbar disc herniation (n = 7, 9.4%), Parkinson's disease (n = 4, 5.4%), meningomyelocele (n = 4, 5.4%), and multiple sclerosis (n = 4, 5.4%)

Before onaBoNT-A injections, on average 5 (4-6), pads were used daily in Group 1, and 6.5 (3.5-7.5) pads in the treatment-refractory Group 2 (p = 0.244). At the 3rd month of the follow-up period after onaBoNT-A injections, on average 3 (1-4) pads were used daily in Group 1, and 6 (3.5-7) pads in Group 2 (p = 0.005) (**Table 1**). There was a statistically significant difference between the values before and after treatment (p < 0.001, p < 0.001, respectively). Changes pad used per day in Group 1 was statistically significant (F(1,65)=162.35, p < 0.001).

Another key indicator of clinical response in our study was the duration of benefit observed after treatment with onaBoNT-A injections. The average duration of benefit in Group 1 was reported to be approximately 6 months (95% Confidence Interval (CI): 5.42-7.04). As stated, the patients in Group 2 did not benefit from the treatment (**Table 1**).

Urodynamics Data

No significant difference was observed between the two groups in terms of the presence of phasic or terminal NDOA (p = 0.564, and p = 0.559, respectively). Although the IDC was higher in Group 1, any statistically significant difference was not observed between both groups (p = 0.534) (Table 2).

Increased DLPP were detected in Groups 1 (n:22 ;33.3%) and 2 (n:5; 62.5%) (p = 0.106). There was no significant difference between the groups in DLPP and DLPV (p = 0.569 and p = 0.237, respectively). Similarly, no significant difference was found between Groups 1 and 2 in terms of MCC (213 ml vs 218 ml, p = 0.742), pVesMax (58 cm H2O vs 43 cm H_2O, p = 0.121), ΔPdet (52.5 cm H_2O vs 38 cm H2O, p=0.098), and bladder compliance (3.95 ml/cm H_2O vs 7.16 ml/cmH_2O, p = 0.156) (**Table 2**).

Subgroup Analysis

In the subgroup analysis conducted on 66 patients who benefited from treatment, the average number of pads used per day (5: range,4-6) in the preoperative period, decreased (n: 3; range 1-2) after the injections [F(1,65) = 162.35, p < 0.001]. A negative weak correlation was observed between the number of pads used per day and MCC (p = 0.024, r = -0.277). Any additional urodynamic efficacy indicator showing a correlation with the change in the number of pads used each day has not been identified, so far (**Table 3**).

Any statistically significant correlations were not observed between the duration of the treatment efficacy of onaBoNT-A injections and MCC, pVesMax, IDC, and DLPV (p = 0.300, r = -0.130; p = 0.225, r=0.151; p = 0.956, r = -0.007; p = 0.877, and r = 0.035, respectively). However, a positive weak correlation was detected between the duration of the treatment efficacy of onaBoNT-A injections and ΔPdet (p = 0.018, r = 0.291), whereas a negative correlation was noticed with bladder compliance (p = 0.035, r = -0.260) (**Table 3**).

The impact of categorical variables on the duration of treatment efficacy of onaBoNT-A injections and change in the number of pads used per day was evaluated through multiple regression analysis. Female sex (B = 1.01,p = 0.211 and B = -0.260, p = 0.417), presence of phasic (B = 0.220, p = 0.784 and B = 0.427, p = 0.204) and terminal NDOA (B = -0.032, p = 0.976 and B = -0.362, p = 0.382), and observed DLPP (B = -1.239, p = 0.151 and B = 0.079, p = 0.834) had no significant effect on treatment duration and pads used per day respectively. Hydronephrosis (B=-3.787, p=0.002) had a significant effect on treatment duration. On the other hand, its effect on daily pad use was B = -0.657 and p = 0.155, which was not found significant in this analysis. Hydronephrosis adversely influenced the duration of treatment efficacy of onaBoNT-A in 21% of the cases. Hydronephrosis shortened the duration of treatment efficacy of onaBoNT-A [F(5,65) = 3.297, p = 0.011]. None of the categorical variables affected the number of pads used per day [F(8,65)=1.316, p = 0.254] (**Table 4**).

DISCUSSION

American Urological Association (AUA)/ Society of Urodynamics, Female Pelvic Medicine & Urogenital Reconstruction (SUFU) Guidelines recommend onaBoNT-A injections for patients with NLUTD who do not respond to or cannot tolerate antimuscarinic therapy [(14)]. A study conducted by Apostolidis et al. employed a 200 IU onaBoNT-A and placebo-controlled design in SCI patients who did not adequately respond to anticholinergic treatment. The results demonstrated the efficacy of the intervention in reducing the incidence of UI episodes (-15.8 episodes/week from baseline in 6th week, p = 0.030) and the duration of the therapeutic effect (15). Researchers comparing onaBoNT-A doses of 200 IU and 300 IU used for the management of NDOA, noted that there was no difference between both treatment modalities in efficacy and duration of action, but the amount of postvoiding residual urine increased and CIC was applied more frequently in patients treated with onaBoNT-A doses of 300 IU[(16)]. In the present study, 200 IU of onaBoNT-A was injected in accordance with the recommendations of the Food and Drug Administration.

Reitz et al. conducted a study where patients who received 300 IU of onaBoNT-A injections due to UI caused by NDOA were monitored with urodynamic

tests performed at 12 and 36 weeks after the injections. In the 12th-week urodynamic assessments of the patients included in the study, increases in MCC, IDC, and bladder compliance, along with a decrease in pVesMax were observed ($p < 0.001$ for all parameters). The authors also noted that that these effects were maintained at the 36-week urodynamic assessment as well [17]. When subjective efficacy was evaluated after onaBoNT-A injections, the time elapsed between the initial injection and the maximum benefit obtained ranged from 7 to 30 days. The effectiveness of onaBoNT-A for NDOA has been reported to persist from 3 months to 11 months[18]. In the present study, we observed a positive correlation between the duration of beneficial effects of onaBoNT-A and ΔPdet and a negative correlation with bladder compliance. In the current literature, the relationship between the duration of beneficial effects of onaBoNT-A and the relevant influential urodynamic parameters has not been investigated so far. Therefore, we believe that the current study could be a pioneering research in this field.

The most common urodynamic dysfunction in patients with NLUTD is NDOA[19]. NDOA is observed in suprasacral cord lesions and affects the UUT by causing an increase in intravesical pressure[20]. A study conducted on adult patients with NLUTD symptoms showed that 37 out of 71 patients experienced symptomatic improvement following intravesical onaBoNT-A injections including 20 (54%) patients with NDOA. There was no significant difference between the groups that did and did not show symptomatic improvement in terms of the presence of NDOA ($p = 0.64$)[21]. The current study also revealed that NDOA was present in 82.4% of the total patient population. Although the percentage of patients with phasic (Group 1:60.6%; Group 2:50%) and terminal NDOA (Group 1:83.3%; Group 2:75%) was higher in Group 1, there was no statistically significant difference between the groups in terms of the presence of phasic and terminal NDOA ($p = 0.564$, $p = 0.559$, respectively). The presence of NDOA did not affect the change in the number of pads used per day or the duration of treatment efficacy of onaBoNT-A injections.

The DLPP is an indicator of UUT damage, and a DLPP of > 40 cm H2O is considered significant. However, according to a study by Tarcan et al., a DLPP of > 40 cm H_2O alone is not sufficient to predict UUT damage [22]. In our study, DLPP was observed in 33.3% of the patients in Group 1 and 62.5% of the patients in Group 2. Among 22 patients with DLPP, 3 (13.6%) cases had hydronephrosis ($p = 0.79$) and DLPP was calculated as 35 ± 17.34 (16-50) cm H_2O. Similar to the study by Tarcan et al., the present study also supported the notion that the presence of DLPP alone did not have an effect on UUT damage. Additionally, the average DLPP was 34 cm H2O in Group 1 and 16 cm H2O in Group 2. The presence of DLPP, DLPP, or DLPV was not predictive of the treatment efficacy of onaBoNT-A ($p = 0.834$, $p = 0.543$, and $p = 0.833$, respectively).

A study evaluating the treatment efficacy of onaBoNT-A based on MCC reported that the magnitude of increase in MCC due to onaBoNT-A application was significantly higher in the < 250 ml group compared to the > 250 ml group[23]. Softness et al. reported that patients with low MCC experienced a dramatically greater increase in their MCC after onaBoNT-A injections and they associated lower MCC with higher treatment efficacy of onaBoNT-A applications[24]. In another study, where the baseline value for compliance was assessed as 10 ml/cm H_2O, it was shown that the compliance of the group benefitting from the treatment was lower [24]. In the current study, although the patients were not grouped based on their MCC, the mean MCC was lower in the group that benefited from treatment ($p = 0.741$). In subgroup analysis, as MCC decreased, a greater reduction in the number of pads used per day was observed following onaBoNT-A injections ($p = 0.024$, r = -0.277).

Many researchers have investigated the effectiveness of onaBoNT-A and its association with detrusor pressure and compliance in NLUTD. For instance, Lee et al. showed that the patients with neurogenic and non-underactive voiding dysfunction who benefited from onaBoNT-A injections, had manifested higher detrusor pressure during voiding with lower MCC[25]. Besides, higher initial detrusor pressure (>110 cm H_2O) was associated with a poor response to treatment[26], Rovner et al. reported an initial detrusor pressure of 24.3 cm H2O in their study and linked higher detrusor pressures to treatment success[27]. In the current study, the median ΔPdet, and compliance values were 52.5 (20-66) cm H_2O, and 3.95 (1.97-8.18) ml/cm H_2O, respectively. A positive correlation was detected between the duration of benefit from treatment and ΔPdet, whereas a negative correlation was found between the treatment response and compliance.

The current study had several limitations, including a restricted sample size, the absence of urodynamic parameter evaluations following onaBoNT-A injections, its retrospective nature, and the reliance on subjective data for the assessment of treatment success, such as pad usage and detailed medical history (including urinary incontinence frequency, voiding frequency, and CIC count). Nevertheless, the primary aim of this research was to investigate the factors influencing the duration of onaBoNT-A injection treatment effectiveness. The duration of onaBoNT-A injection is positively influenced by elevated ΔPdet and reduced compliance. Reduction in the number of pads used per day was observed following onaBoNT-A injections, in line with the decrease in MCC.

CONCLUSIONS

OnaBoNT-A injection is an effective and minimally invasive treatment option for NLUTD. This study stands out among others in that it examined numerous urodynamics and clinical parameters that influence the efficacy of onaBoNT-A in the treatment of UI, and the duration of its effectiveness. In the current study, except for MCC, none of the urodynamic parameters (ΔPdet, pVesMax, compliance, DLPP, NDOA) could predict treatment response. In the subgroup analysis, it was observed that as MCC decreased in patients who benefited from onaBoNT-A injections, the number of pads used daily after injections decreased more significantly. Patients with higher ΔPdet and low compliance benefited longer from onaBoNT-A injections.

Availability of Data and Materials

The datasets used and/or analysed during the current study were available from the corresponding author on reasonable request.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

1. Chen PC, Lee KH, Lee WC, et al. Treating Neurogenic Lower Urinary Tract Dysfunction in Chronic Spinal Cord Injury Patients-When Intravesical Botox Injection or Urethral Botox Injection Are Indicated. Toxins (Basel) 2023;15.
2. Huang M, Chen H, Jiang C, et al. Effects of botulinum toxin A injections in spinal cord injury patients with detrusor overactivity and detrusor sphincter dyssynergia. J Rehabil Med 2016;48:683–7.
3. Andersson KE. Antimuscarinic mechanisms and the overactive detrusor: an update. Eur Urol 2011;59:377–86.
4. Stöhrer M, Blok B, Castro-Diaz D, et al. EAU guidelines on neurogenic lower urinary tract dysfunction. Eur Urol 2009;56:81–8.
5. Schurch B, Stöhrer M, Kramer G, Scgmid DM, Gaul G, Hauri D. Botulinum-A toxin for treating detrusor hyperreflexia in spinal cord injured patients: a new alternative to anticholinergic drugs? Preliminary results. J Urol 2000;164:692–7.
6. Jiang Y-H, Jhang J-F, Chen S-F, Kuo H-C. Real-Life Treatment Outcome of Botulinum Toxin A Injection on Overactive Bladder and Voiding Dysfunction in Patients with Central Nervous System Lesions. Toxins (Basel) 2024;16:123.
7. Grise P, Ruffion A, Denys P, Egon G, Chartier Kastler E. Efficacy and tolerability of botulinum toxin type A in patients with neurogenic detrusor overactivity and without concomitant anticholinergic therapy: comparison of two doses. Eur Urol 2010;58:759–66.
8. Chen Y, Peng L, Zhang C, et al. The effectiveness and safety of oral medications, onabotulinumtoxinA (three doses) and transcutaneous tibial nerve stimulation as non or minimally invasive treatment for the management of neurogenic detrusor overactivity in adults: a systematic review and network meta-analysis. Int J Surg 2023;109:1430–8.
9. Cheng T, Shuang WB, Jia DD, et al. Efficacy and Safety of OnabotulinumtoxinA in Patients with Neurogenic Detrusor Overactivity: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. PLoS One 2016;11.
10. Schurch B, De Sèze M, Denys P, et al. Botulinum toxin type a is a safe and effective treatment for neurogenic urinary incontinence: results of a single treatment, randomized, placebo controlled 6-month study. J Urol 2005;174:196–200.
11. Abrams P, Cardozo L, Fall M, et al. The standardisation of terminology of lower urinary tract function: report from the Standardisation Sub-committee of the International Continence Society. Neurourol Urodyn 2002;21:167–78.
12. Rosier PFWM, Schaefer W, Lose G, et al. International Continence Society Good Urodynamic Practices and Terms 2016: Urodynamics, uroflowmetry, cystometry, and pressure-flow study. Neurourol Urodyn 2017;36:1243–60.
13. El-Hefnawy AS, Elbaset MA, Taha DE, et al. Trigonal-sparing versus trigonal-involved Botox injection for treatment of idiopathic overactive bladder: A randomized clinical trial. Low Urin Tract Symptoms 2021;13:22–30.
14. Ginsberg DA, Boone TB, Cameron AP, et al. The AUA/SUFU Guideline on Adult Neurogenic Lower Urinary Tract Dysfunction: Diagnosis and Evaluation. J Urol 2021;206:1097–105.
15. Apostolidis A, Thompson C, Yan X, Mourad S. An exploratory, placebo-controlled, dose-response study of the efficacy and safety of onabotulinumtoxinA in spinal cord injury patients with urinary incontinence due to neurogenic detrusor overactivity. World J Urol 2013;31:1469–74.
16. Cruz F, Herschorn S, Aliotta P, et al. Efficacy and safety of onabotulinumtoxinA in patients with urinary incontinence due to neurogenic detrusor overactivity: a randomised, double-blind, placebo-controlled trial. Eur Urol 2011;60:742–50.
17. Reitz A, Stöhrer M, Kramer G, et al. European experience of 200 cases treated with botulinum-A toxin injections into the detrusor muscle for urinary incontinence due to neurogenic detrusor overactivity. Eur Urol 2004;45:510–5.
18. Smaldone MC, Ristau BT, Leng WW. Botulinum toxin therapy for neurogenic detrusor overactivity. Urol Clin North Am 2010;37:567–80.
19. Bo K, Frawley HC, Haylen BT, et al. An International Urogynecological Association (IUGA)/International Continence Society (ICS) joint report on the terminology for the conservative and nonpharmacological management of female pelvic floor dysfunction. Int Urogynecol J 2017;28:191–213.
20. Weld KJ, Wall BM, Mangold TA, Steere EL, Dmochowski RR. Influences on renal function in chronic spinal cord injured patients. J Urol 2000;164:1490–3.
21. O'Connor RC, Johnson DP, Guralnick ML. Intradetrusor botulinum toxin injections (300 units) for the treatment of poorly compliant bladders in patients with adult neurogenic lower urinary tract dysfunction. Neurourol Urodyn 2020;39:2322–8.
22. Tarcan T, Demirkesen O, Plata M, Castro-Diaz D. ICS teaching module: Detrusor leak point pressures in patients with relevant neurological abnormalities. Neurourol Urodyn 2017;36:259–62.
23. Kuo HC, Liao CH, Chung SD. Adverse events of intravesical botulinum toxin a injections for

idiopathic detrusor overactivity: risk factors and influence on treatment outcome. Eur Urol 2010;58:919–26.

24. Softness KA, Thaker H, Theva D, Rajender A, Cilento BG, Bauer SB. Onabotulinumtoxin A (Botox): A reasonable alternative for refractory neurogenic bladder dysfunction in children and young adults. Neurourol Urodyn 2021;40:1981–8.
25. Lee YK, Kuo HC. Therapeutic Effects of Botulinum Toxin A, via Urethral Sphincter Injection on Voiding Dysfunction Due to Different Bladder and Urethral Sphincter Dysfunctions. Toxins (Basel) 2019;11.
26. Sahai A, Khan MS, Le Gall N, Dasgupta P. Urodynamic assessment of poor responders after botulinum toxin-A treatment for overactive bladder. Urology 2008;71:455–9.
27. Rovner E, Kennelly M, Schulte-Baukloh H, Zhou J, Haag-Molkenteller C, Dasgupta P. Urodynamic results and clinical outcomes with intradetrusor injections of onabotulinumtoxinA in a randomized, placebo-controlled dose-finding study in idiopathic overactive bladder. Neurourol Urodyn 2011;30:556–62.