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Experience with Intravesical Botox in Meningomyelocele-Related Bladder Dysfunction-A Single-Center Experience

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Abstract
Neurogenic bladder dysfunction as a secondary effect of meningomyelocele (MMC) is a serious risk factor of urinary incontinence, vesicoureteral reflux, and progressive upper urinary tract degradation. This was a prospective, single-centre, study that assessed the short-term effectiveness of intravesical onabotulinumtoxinA (Botulinum toxin type A) in children with refractory neurogenic bladder related to MMC. Ten hyper-reflexive neurogenic bladder children who were unresponsive or intolerant to anticholinergic treatment and clean intermittent catheterization were injected with intrapetrous onabotulinumtoxinA (10 IU/kg) under cystoscopic guidance. The baseline and 3 and 6 months post-treatment assessments were conducted on the urodynamic parameters, the state of continence, bowel symptoms, and vesicoureteral reflux. Three months later, the detrusor sphincter dyssynergia was reduced significantly, the maximum detrusor pressure also decreased significantly, the bladder capacity was higher, the post-void residual volumes were lower, and the grades of continence were better. The moderate grades of vesicoureteral reflux had significant improvement on follow-up voiding cystourethrography. In spite of the fact that partial attenuation of therapeutic effects was observed at 6 months, the results were better than baseline. Also, constipation was improved in most of the patients. These results justify the use of intravesical onabotulinumtoxinA as a safe and useful minimally invasive therapeutic intervention in the short-term management of the bladder in children with MMC-related neurogenic bladder, which may delay or prevent more invasive surgical procedures.

Keywords
Meningomyelocele; Neurogenic bladder; Intravesical botulinum toxin; Pediatric urology; Detrusor overactivity; Vesicoureteral reflux

1. Introduction

Neurogenic lower urinary tract dysfunction is an important and prevalent issue in meningomyelocele patients [1]. These patients have a high risk of urinary incontinence, vesicoureteral reflux (VUR), frequent urinary tract infections, and progressive renal dysfunction Detrusor sphincter dyssynergia (DSD), which is common in this group, increases the risk of inefficient voiding and further increases of bladder pressures [2]. The traditional management involves anticholinergic drugs and clean intermittent catheterization (CIC), which is intended to maintain the renal functions and attain continence. Nevertheless, the adverse effects of long-term adherence can be poor because of its side effects like dry mouth, constipation, and behavioural intolerance in children. In case of failure of conservative therapies, surgical procedures such as augmentation cystoplasty are also an option, but they are associated with high risks of severe complications such as bladder stones, infections and metabolic disorders [3]. Botulinum toxin type A is a neuromodulator that prevents the release of acetylcholine in neuromuscular junctions, which causes temporary chemodenervation and suppression of muscle overactivity. *Clostridium botulinum* is a Gramme-positive anaerobic bacillus that produces the toxin and forms several serotypes, types A and B of which are used in the clinical practise today. Type A is stronger and has a longer therapeutic effect than type B which is evidenced by electromyographic

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studies. These pharmacologic characteristics render botulinum toxin type A an ideal option in the treatment of disorders of involuntary muscle contractions or abnormal neural signalling [4].

BoNT-A has become a promising minimally invasive treatment in refractory neurogenic bladder in the last decade. BoNT-A inhibits the release of acetylcholine at presynaptic terminals and thereby decreases detrusor overactivity, increases bladder compliance, and could also inhibit the afferent sensory input, which improves urgency symptoms [2]. A range of studies in children and patients with neurogenic detrusor overactivity have demonstrated improvements in bladder capacity, detrusor pressures, and continence with a meta-analysis demonstrating a reduction in pressure (~25.2 cm H 2 O) and incontinence resolution in 73% of cases. The first account of Sphincter injection of botulinum toxin A was by Dykstra et al in patients with detrusor-sphincter dyssynergia [5]. There was limited data on the subgroup of meningomyelocele. Also, the effects of BoNT-A have been known to decrease after 4-6 months, which requires repeat administration.

Neuropathic dysfunction of the bladder, especially in children with Meningomyelocele (MMC), is a major clinical problem. The most prevalent cause of neuropathic bladder in children is MMC which commonly causes a hyper-reflexive neurogenic bladder with involuntary detrusor contractions, elevated intravesical pressures, and poor bladder compliance. These conditions may result in the deterioration of the upper urinary tract, vesicoureteral reflux, frequent urinary tract infections, and eventually chronic kidney disease in case of untreated conditions [4]. The main objectives of the management include attaining a low-pressure, high-capacity bladder reservoir, safeguarding the upper tracts, and attaining social continence. The conventional first-line interventions involve anticholinergic drugs (to reduce detrusor overactivity) and Clean Intermittent Catheterization (CIC) (to be able to empty the bladder completely). Nevertheless, some patients have poor response or intolerance to these conservative interventions, which warrant other or complementary therapies [6].

Over the last few years, intravesical Botox Type A (BoNT-A) has become a safe and effective alternative to refractory neurogenic detrusor overactivity (NDO) treatment due to its minimal invasiveness and high efficacy. The action mechanism is the inhibition of the release of acetylcholine at the neuromuscular junction, which causes a localised and temporary chemo denervation of the detrusor muscle, which causes a reduction in detrusor contractility, a drop in intravesical pressure, and in many cases an increase in bladder capacity. Its therapeutic success has been attributed to the dual effect on efferent motor pathways and afferent sensory inputs. In the case of the paediatric MMC population, several studies that have been published within the past five years have shown the usefulness of BoNT-A. A meta-analysis and systematic review by Yuan et al., which compared various clinical trials on patients with neurogenic detrusor overactivity treated with onabotulinumtoxinA, showed that urodynamic outcomes, including a significant increase in maximal cystometric capacity and a significant decrease in maximal detrusor pressure, and a significant improvement in urinary incontinence outcomes, were significant [7]. The overall efficacy and safety of botulinum toxin-A (BoNT-A) injections in children with neurogenic bladder was confirmed by Zulli et al. over the past decade of the research, stating that BoNT-A is a useful second-line approach that may frequently prevent more invasive surgical procedures, including augmentation cystoplasty [8]. Additionally in favour of this, a retrospective study of patients with paediatric neurogenic detrusor overactivity showed that intravesical injection of BoNT-A was a safe and effective intervention with a high global response assessment score (77.8% of patients attained GRA ≥2) and low rate of adverse events including urinary tract infection [9]. This emphasises that larger prospective trials are still required but the existing evidence comprising of recent clinical trials and reviews indicates strongly in favour of the role of intravesical BoNT-A as a second-line therapeutic option in children with myelomeningocele (MMC) and other high-risk hyper-reflexive bladders who have failed standard medical management. Systematic reviews have documented its overall efficacy and safety in improving continence and urodynamic parameters, and narrative reviews describe its potential to delay or avoid more invasive procedures such as augmentation cystoplasty when medical treatments prove inadequate [10,11]. Retrospective clinical data also suggest that commonly employed dosing regimens are associated with favorable safety profiles, with relatively low adverse event rates such as mild urinary tract infections reported in pediatric NDO populations [12].

This study evaluates short-term outcomes (3 and 6 months) of BoNT-A injection in meningomyelocele patients, assessing urodynamic parameters (Detrusor sphincter dyssynergia, detrusor pressures, post-void residuals), clinical improvements (incontinence, constipation), and upper tract outcomes (VUR), aiming to clarify its role in early bladder management in this population.

2. Materials and Methods

2.1 Study Design and Patient Population

This was a prospective, single-center study examining the efficacy of intravesical Botulinum toxin Type A injections in pediatric patients with neuropathic bladder secondary to Meningomyelocele (MMC). The study included a total of 10 subjects and data were collected over a one-year period, from September 2024 to September 2025.

Inclusion criteria were:

- Diagnosis of neuropathic bladder secondary to varying degrees of MMC.
- Age less than 10 years (mean age: 6 ± 4.5 years).
- Failure or intolerance to conventional management, including anticholinergic drugs and Clean Intermittent Catheterization (CIC).
- Presence of a hyper-reflexive neurogenic bladder confirmed by baseline Urodynamic Studies (UDS).
- No history of previous bladder or urethral surgery within the preceding two years.

2.2 Baseline Characteristics

A total of ten patients were included in the study, of whom four were female and six were male. Baseline urodynamic evaluation demonstrated detrusor-sphincter dyssynergia (DSD) in nine of the ten children. At baseline, the mean maximal detrusor pressure (Pdet max) was 133.1 ± 98.7 cm H_2O, the mean post-void residual urine volume was 98.6 ± 70.45 mL, and the mean bladder capacity was 182.4 ± 80.4 mL.

2.3 Intervention

All patients underwent a single intravesical injection of Botulinum toxin Type A (BoNT-A) under General Anesthesia (GA) with cystoscopic guidance (Figure 1). The BoNT-A dose administered was 10 IU/kg of body weight. The injection was distributed into 40 distinct points within the detrusor muscle, carefully sparing the trigone area to minimize the risk of vesicoureteral reflux or other trigonal-related side effects.

Figure 1: Botulinum Toxin type A used in our study

2.4 Follow-up

The patients were followed up post-procedure with clinic visits and repeat evaluations at 3 months and 6 months post-injection. The main outcomes to be assessed will be described in the results section, but they will involve changes in urodynamic parameters, assessment by VCUG after 3 months and clinical measures of continence and bladder control.

3. Results

Study characteristics are summarized in Table 1.The age at initial BTX-A injections ranged between 5.4 and 9.5 (mean age 7.45 ± 2.5).

Table 1: Cystometric Variables at baseline and after intervention at 3 and 6 months

Variables	Baseline	At 3 months	At 6 months
D-S Dyssynergia (Out of 10) on UDS	9	3	5
Pdet Max (cm of H2O)	133.1±98.7	63.5±27.43	78.2±34.5
Post-Void residue (ml)	98.6±70.45	85.4±65.45	89.34±71.45
Bladder Capacity (ml)	182.4±80.4	236.5±85.4	227.4±82.67

3.1 Urodynamic Findings

This study evaluates the impact of intravesical OnabotulinumtoxinA (Botox type A) on key urodynamic parameters in patients with detrusor overactivity and detrusor sphincter dyssynergia. Cystometric assessments were performed at baseline and subsequently repeated at 3 and 6 months post-injection (summarised in Table 1) to monitor functional changes in bladder performance.

At 3 months, there was a marked and statistically meaningful improvement across multiple parameters compared to baseline. Detrusor sphincter dyssynergia scores reduced substantially from 9 to 3, indicating a significant reduction in outflow resistance and better coordination during voiding. Maximum detrusor pressure decreased from 133.1±98.7 cm H_2O to 63.5±27.43 cm H_2O, reflecting a notable reduction in high-pressure storage that poses risk to upper urinary tracts. Bladder capacity increased from 182.4±80.4 ml to 236.5±85.4 ml, suggesting improved compliance and storage ability. Post-void residual volume also showed a favorable decline. These findings demonstrate that the peak therapeutic effect of intravesical Botox is achieved around the 3-month mark.

By 6 months, although improvements remained better than baseline, the degree of benefit showed partial decline. Dyssynergia scores rose to 5, detrusor pressures increased to 78.2±34.5 cm H_2O, and bladder capacity slightly reduced to 227.4±82.67 ml. These trends suggest a waning therapeutic response after the 3-month peak, consistent with the known duration of Botox pharmacologic activity, supporting the need for repeat dosing to maintain optimal bladder dynamics.

3.2 Incontinency and Constipation

Incontinence severity was assessed using the Schurch grading system [13]. Urinary incontinence was categorized into four grades (0-3) based on the frequency of urine leakage and the need for protective measures between catheterizations.

Table 2. Grading system for severity of urinary incontinence used in the study

Grade		Description
0	**Complete continence**	no urine leakage between catheterizations.
1	**Mild incontinence**	occasional leakage, not requiring pads, mostly during increased intra-abdominal pressure (e.g., coughing, laughing).
2	**Moderate incontinence**	intermittent leakage requiring occasional pad use or changes of clothing.
3	**Severe Incontinence**	Continuous or frequent leakage requiring regular use of pads or condom catheter

The changes in distribution of grades over time reflect the therapeutic benefit of intravesical Botulinum toxin A. At baseline, the majority of patients exhibited higher grades of incontinence, indicating significant sphincteric dysfunction (Table 3). Following treatment, a notable improvement was observed at the 3-month follow-up, with increased frequencies in lower grades. Specifically, grade 0 incontinence increased from just 1 patient at baseline to 4 patients at 3 months, while grade 3 incontinence declined from 5 to 1 patient, demonstrating meaningful enhancement in continence status. At 6 months, this improvement was still evident compared to baseline, although the degree of benefit had slightly regressed from the 3-month peak response. Grade 0 remained better than baseline at 3 patients, while higher grades showed minor increases from 3-month levels. Overall, intravesical Botox resulted in reduced incontinence severity, with the most pronounced improvement at 3 months, followed by a partial decline by 6 months, consistent with the expected duration of effect shown in Figure 2. Beyond primary bladder improvements, secondary benefits for bowel function have also been observed. In this study, subjective symptoms of constipation improved significantly, reported by 9 patients at the 3-month follow-up, and remaining stable in 7 patients by the 6-month mark.

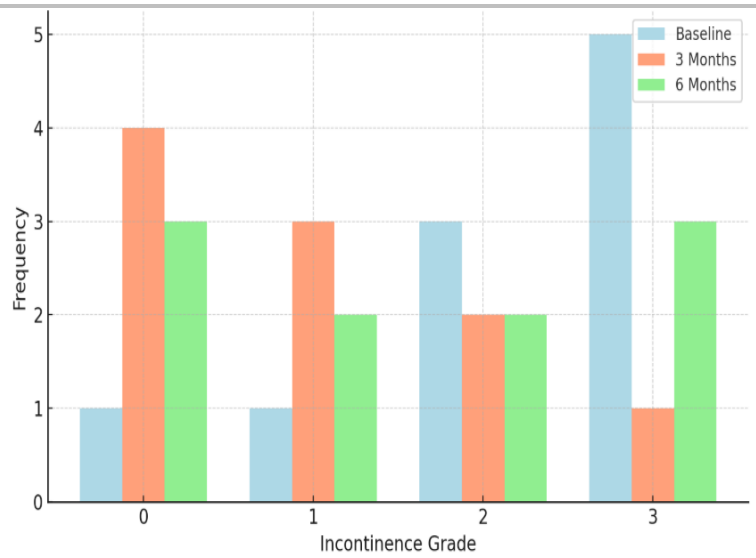

Figure 2: Showing grades of incontinence and frequency at baseline, at 3 months and at 6 months

Table 3: Incontinence Grades and Frequency at baseline, and at 3 and 6 months

Incontinence Grade	Baseline (Out of 10)	Frequency at 3 months (out of 10)	Frequency at 6 months (Out of 10)
0	1	4	3
1	1	3	2
2	3	2	2
3	5	1	3

This compelling co-improvement is likely explained by the common neural pathways supplying both the lower urinary tract and the distal bowel. Specifically, both organs share significant parasympathetic and somatic innervation arising from the sacral spinal cord segments (S2-S4) [14,15], providing an anatomical basis for the observed linked therapeutic effect.

3.3 Voiding Cysto-urethrography (VCUG)

In this study involving 10 patients with meningomyelocele who underwent intravesical Botulinum toxin A (BoNT-A) injection, a reduction in the grade of vesicoureteral reflux (VUR) was observed at 3 months post-intervention. Figure 3 illustrates the distribution of vesicoureteral reflux (VUR) grades at baseline in the study cohort.

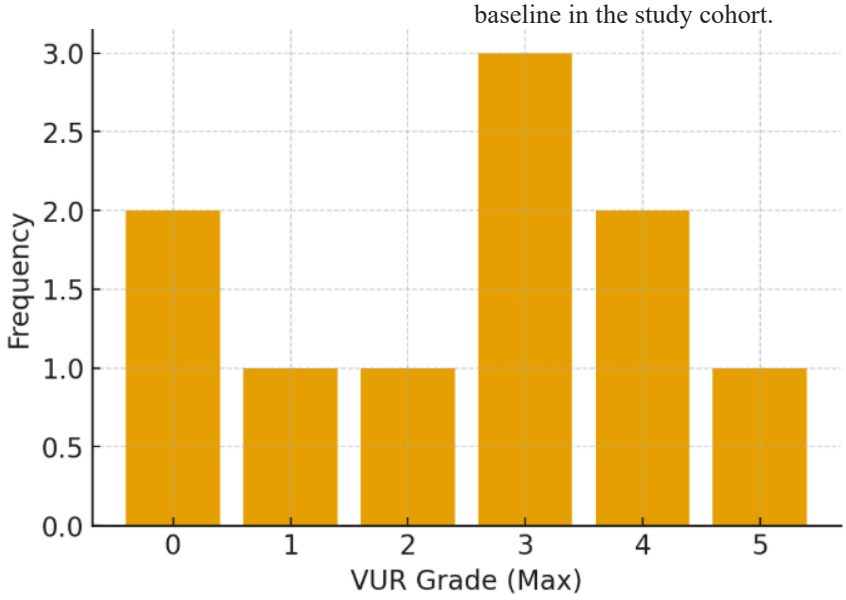

Figure 3: Showing relationship of Grade of VUR and Frequency at baseline

Specifically, grades 3 and 4 VUR showed improvement, with the frequency of grade 3 decreasing from 3 to 1 and grade 4 from 2 to 1, whereas grade 5 VUR remained unchanged (Figure 4). This suggests that BoNT-A may be more effective in moderate reflux than in severe cases, likely due to partial restoration of bladder compliance and reduced detrusor overactivity (Table 4).

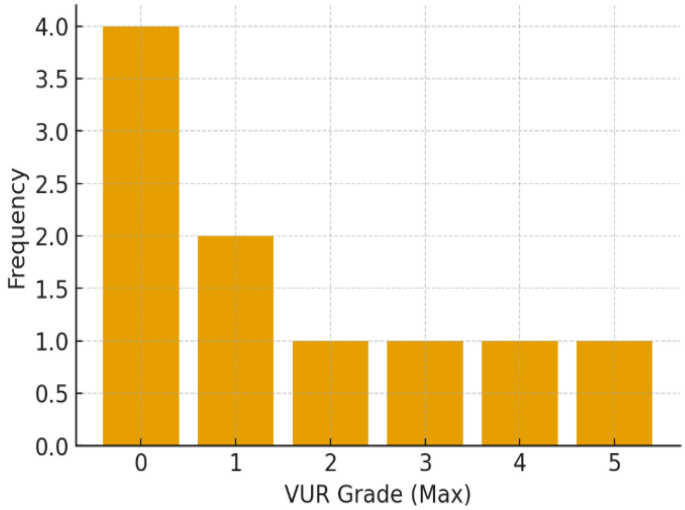

Figure 4: Showing relationship of grade of VUR at 3 months after Intravesical Botox type A as evaluated by VCUG

Table 4: Showing the frequency of VUR at baseline and at 3 months, as evaluated by VCUG

VUR Grade (Maximum)	Baseline Frequency (Out of 10)	Frequency at 3 months (Out of 10)
0	2	4
1	1	2
2	1	1
3	3	1
4	2	1
5	1	1

4. Discussion

In the current research, Botulinum Toxin Type A (BoNT-A) intravesical injected in children with meningomyelocele led to significant changes in urodynamic and clinical outcomes of lower urinary tract functioning. The most significant improvements were found at the three-month follow-up, with a significant decrease in detrusor-sphincter dyssynergia (DSD), a significant reduction in maximum detrusor pressures, an increase in bladder capacity, and an increase in continence. Despite the observed partial attenuation of therapeutic effects at six months, the results were still better than baseline, which highlights the short-term effectiveness of BoNT-A in this high-risk pediatric group.

The decreased DSD is a finding that is especially relevant since the condition has a significant role in the increasing intravesical pressures and ineffective bladder emptying among children with meningomyelocele. The observed increase in sphincter coordination at three months is probably due to the combined inhibitory action of BoNT-A on the detrusor muscle contractility and sphincter overactivity. The transient chemodenervation effect of BoNT-A is mild and consistent with the established temporary nature of the effect and is in line with previous reports of a duration of action of between four and six months [16]. Notably, despite this reduction, urodynamic parameters were still better than at baseline indicating a long-term partial benefit.

The functional relevance of these urodynamic changes is also supported clinically by decreases in the severity of urinary incontinence and post void residual volumes. Enhanced bladder emptying does not only contribute to better continence, but could also decrease the chances of urinary tract infection and upper tract degradation. The fact that the symptoms of constipation have improved in most patients demonstrates a positive side effect of BoNT-A therapy. Since both the bladder and distal bowel share the same sacral innervation, better voiding dynamics can be used to support more coordinated pelvic floor activity, which will result in the alleviation of bowel symptoms [17–19].

The protective effect of BoNT-A on the upper urinary tracts is further supported by the improvement of the vesicoureteral reflux (VUR) grades on subsequent VCUG. The lowering of moderate grades of reflux is probably due to reduced detrusor pressure at the time of storage and voiding, which leads to reduced retrograde urine flow. Safari et al. reported large decreases in VUR grade and better bladder dynamics after intravesical

BoNT-A injections in children with neuropathic bladder dysfunction [20], and systematic reviews have all shown clinically meaningful improvements in reflux and urodynamic outcomes with BoNT-A therapy in paediatric neurogenic bladder populations [2,20,21].

The results of the present research are also aligned with the more recent literature that supports the use of BoNT-A as a second-line treatment in the management of neurogenic bladder. Yu and Wang et al. have noted that BoNT-A treatment of children has resulted in significant improvements in detrusor pressures, bladder capacity, and incontinence episodes [22]. Harten et al. reported a decrease in detrusor pressure and post-void residual volumes, as well as the enhancement of continence and VUR, in children with myelomeningocele receiving BoNT-A [23]. Taken together, these studies suggest the reproducibility of our findings in other cohorts and study designs.

BoNT-A has a temporary effect, the therapeutic profile has significant clinical benefits. BoNT-A can delay or decrease the occurrence of more invasive surgical procedures like augmentation cystoplasty by offering a minimally invasive procedure that leads to improved bladder safety and continence, especially in younger children. Although the repeated injections might be necessary to sustain the long-term benefits, the positive safety profile of the drug in this and previous studies justifies its further use as a step-by-step approach to managing the bladder.

5. Conclusions

Intravesical botulinum toxin type A is a safe and moderately effective treatment alternative to children with neurogenic bladder related to meningomyelocele who do not respond sufficiently to traditional medical treatment, such as anticholinergic therapy and clean intermittent catheterization. BoNT-A therapy, in this prospective single-centre experience, produced significant short-term urodynamic and clinical outcomes, such as decreased detrusor pressures, detrusor-sphincter dyssynergia, post-void residual volumes, urinary incontinence severity, and selected grades of vesicoureteral reflux, and thus, improved bladder safety and bladder function. The intrapetrous and intrasphincter combination technique seemed to have better short-term functional outcome than intrapetrous injections, which indicated that a combination of storage and outlet dysfunction could be the most effective in terms of therapeutic outcome in patients with complex bladder-sphincter dyssynergia. Despite the fact that the therapeutic effects were partially attenuated by six months, the results were still better than at baseline, which is in line with the established pharmacologic profile of BoNT-A. These results justify the use of intravesical BoNT-A as a useful second-line intervention, which is minimally invasive and can delay or minimise the necessity of more invasive reconstructive interventions in a selected group of paediatric patients. The role of long-term efficacy, optimum dosing schedule and standardised injection regimen needs to be further clarified by larger, multicenter studies with longer-term follow-up to better define long-term efficacy, optimal dosing schedule, and standardised injection regimen to further refine its place in the management of meningomyelocele-related neurogenic bladder.

Conflicts of Interests – Authors declare the absence of any conflict of interests and own financial interest that might be construed to influence the results or interpretation of the manuscript.

Author's contribution.

Dr.Sonali Bijjargi – conceptualization, data curation, investigation, methodology, resources, project administration, original draft, review and editing;

Dr.Vishal Kadeli - conceptualization, data curation, investigation, methodology, resources, original draft, review and editing

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