

Opinion

# Urological Management of the Spinal Cord-Injured Patient: Suggestions for Improving Intermittent Catheterization and Reflex Voiding

James Walter <sup>1,2,\*</sup>, John Wheeler <sup>1,3</sup>, Raymond Dieter <sup>2</sup>, Brandon Piyevsky <sup>4</sup> and Aasma Khan <sup>5</sup>

<sup>1</sup> Department of Urology, Loyola Medical Center, Maywood, IL 60153, USA

<sup>2</sup> Research Service, Hines VA Hospital, Hines, IL 60141, USA

<sup>3</sup> Department of Surgery, Hines VA Hospital, Hines, IL 60141, USA

<sup>4</sup> Boonshoft School of Medicine, Wright State University, Fairborn, OH 45435, USA

<sup>5</sup> Department of Psychology, Chicago State University, Chicago, IL 60628, USA

\* Correspondence: jameswalter889@gmail.com

**Abstract:** Spinal cord injury can either be complete with no neural communication across the injury level or incomplete with limited communication. Similarly, motor neuron injuries above the sacral spinal cord are classified as upper motor neuron injuries, while those inside the sacral cord are classified as lower motor neuron injuries. Specifically, we provide recommendations regarding the urological management of complete upper motor neuron spinal cord injuries; however, we also make limited comments related to other injuries. The individual with a complete upper motor neuron injury may encounter five lower urinary tract conditions: *first*, neurogenic detrusor overactivity causing urinary incontinence; *second*, neurogenic detrusor underactivity resulting in high post-void residual volumes; *third*, detrusor sphincter dyssynergia, which is contraction of striated and/or smooth muscle urethral sphincters during detrusor contractions; *fourth*, urinary tract infection; and *fifth*, autonomic dysreflexia during detrusor contractions, which produces high blood pressure as well as smooth muscle detrusor sphincter dyssynergia. Intermittent catheterization is the recommended urinary management method because it addresses the five lower urinary tract conditions and has good long-term outcomes. This method uses periodic catheterizations to drain the bladder, but also needs bladder inhibitory interventions to prevent urinary incontinence between catheterizations. Primary limitations associated with this management method include difficulties with the multiple catheterizations, side effects of bladder inhibitory medications, and urinary tract infections. Three suggestions to address these concerns include the use of low-friction catheters, wireless, genital-nerve neuromodulation for bladder inhibition, and consideration of urine egress into the urethra as a risk factor for UTI as well as egress treatment. The second management method is reflex voiding. This program uses external condoms for urine collection in males and diapers for females. Suprapubic tapping is used to promote bladder contractions. This method is not recommended because it has high rates of medical complications. In particular, it is associated with high detrusor pressure, which can lead to ureteral reflux and kidney pathology. Botulinum toxin injection into the urethral striated sphincter can manage detrusor sphincter dyssynergia, reduce voiding pressures, and risks to the kidney. We suggest a modified method for botulinum toxin injections as well as five additional methods to improve reflex voiding outcomes. Finally, the use of intermittent catheterization and reflex voiding for individuals with incomplete spinal injuries, lower motor neuron injuries and multiple sclerosis are briefly discussed.

**Keywords:** lower urinary tract; urinary incontinence; urinary tract infections; detrusor sphincter dyssynergia; spinal cord injury; neurogenic detrusor overactivity; neurogenic detrusor underactivity; autonomic dysreflexia



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## 1. Introduction

If there is no neural injury present, the pontine micturition center coordinates bladder filling to prevent incontinence with increased urethral sphincter contraction and bladder inhibition. During voiding, the detrusor muscle and urethral striated sphincter are contractions of the pontine center, which are responsible for the control of micturition [1]. Spinal cord injury (SCI) is a major neurological injury that disrupts the pontine micturition center control of urination [2–4]. Bladder contractions for these individuals cannot be predicted and voiding is described as urinary incontinence. We primarily discuss the urological management of complete SCI above the sacral spinal cord, an upper motor neuron (UMN) injury. Five conditions need to be taken into consideration for these patients. *First*, neurogenic detrusor overactivity (NDO), which is the nonvolitional bladder contractions and associated with urinary incontinence [3]. *Second*, neurogenic detrusor underactivity (NDU) is characterized by short duration bladder contractions that result in high post-void residuals (PVR) [3]. *Third*, detrusor striated sphincter dyssynergia (DSD), which is urethral striated sphincter contractions and is caused by spinal reflex responses to detrusor contractions. Constricted urethras are associated with high PVRs and high detrusor pressures, which can lead to kidney damage and ureteral reflux [5–9]. *Fourth*, for complete UMN SCI at and above the 6th thoracic vertebra, detrusor contractions can lead to autonomic dysreflexia (AD), which is a generalized sympathetic discharge producing high blood pressure and constriction of urethral smooth muscle (bladder neck/proximal urethra), a second type of DSD [2,10]. *Fifth*, urinary tract infections (UTI) are a major concern for these individuals [11–13].

Two common methods of bladder management for complete UMN SCI are intermittent catheterization (IC) and reflex voiding (RV) [3,7,14,15]. IC is a recommended management method because of good long-term outcomes, whereas RV is not recommended because of the high risk of complications. In addition, both management methods have significant quality of life (QoL) concerns for patients [16–18]. Suggestions are presented for addressing medical problems and QoL concerns for both IC and RV. In addition, briefly discussed are IC and RV for individuals with incomplete spinal injuries, lower motor neuron injuries and multiple sclerosis.

## 2. Intermittent Catheterization (IC)

The preferred method of urological management for patients with UMN SCI is IC, which involves draining the bladder with catheterizations at 3–5 h intervals. A detrusor muscarinic receptor antagonist (MRA) is usually used to treat NDO and urinary incontinence between catheterizations [7]. IC is recommended for urinary management because of good outcomes with limited complications [14–16]. DSD is nullified by the catheter being inserted past the urethral striated sphincter. NDU is not a problem because NDU is associated with reduced detrusor contraction, which is one of the goals of an IC program [3]. AD is managed by the MRA treatment which reduces detrusor contractions [10]. Quality-of-life (QoL) studies for individuals using IC, however, have determined that patients are having problems [16–18]. Three QoL concerns with IC are presented below along with suggestions to improvements.

*Suggestion 1, low-friction catheters:* some patients using IC have difficulty with the need for the frequent catheterizations, resistance to catheter insertion, urethral strictures, and false passages [14–16]. We suggest the use of low-friction catheters, which have been shown to reduce catheter-related problems (Table 1) [19]. A search of the World Wide Web can provide more information about low-friction catheters where they can also be purchased.

**Table 1.** For complete UMN SCI, three problems and suggestions for IC management.

Problem	Suggestion
1. Catheterization trauma and frequency	Use low-friction catheters
2. MRAs for bladder inhibition	Use genital nerve wireless TENS
3. High rates of UTI	Consider urine egress and treatment

*Suggestion 2, wireless, genital-nerve, transcutaneous electrical stimulation:* incontinence between catheterizations is typically prevented by drugs that block detrusor muscarinic receptors (MRAs) important for detrusor contractions [2,3]. Side effects from these drugs, however, include drowsiness, dry mouth, and dementia risk [16,20,21]. There are alternative treatments available, including beta-3-adrenergic agonists, injections of botulinum toxin (BT) into the detrusor, bladder augments, and transcutaneous electrical nerve stimulation (TENS) with surface electrodes [2,16,20–22]. We suggest TENS of the genital nerve is a promising alternative to MRAs for bladder inhibition. Preliminary studies in SCI patients demonstrates NDO inhibition ([23], reviewed in this Special Issue of *Uro*). The dangling wires required between the stimulator and surface electrodes have proven to be a problem with this method, which is rarely used in clinical practice. Thus, we recommend the use of wireless TENS that do not require any wires (Table 1).

*Suggestion 3, consideration of urine egress from the bladder into the urethra:* the average rate of UTI for individuals with SCI is 2.5 events per year [3,13]. A primary risk factors for this major morbidity is repeated catheter passages, which can move bacteria into the bladder. The use of low-friction catheters, suggested above, can help reduce this risk. Another risk is urine stasis, which can be reduced by effective bladder drainage with the catheter [13]. Urinary incontinence is another UTI risk factor, which needs to be managed with bladder inhibitory interventions [14,15]. An unrecognized UTI risk factor is urine egress from the bladder into the urethra during the period between catheterizations. Urine egress reduces the distance that bacteria migrate up the urethra to access the bladder. We recently reported on this potential UTI risk for nonneurogenic women ([24], reviewed in this Special Issue of *Uro*), and now we are extending those arguments to neurogenic bladder management. Video urodynamics using radiopaque medium for bladder filling can be used to diagnose increased detrusor pressures and urine egress [24]. If increased pressures and egress are observed, we suggest that bladder inhibitory intervention would be needed to reduce these risks. Bladder inhibitory interventions beyond just incontinence management would be needed (Table 1).

### 3. Reflex Voiding (RV)

This method relies on spontaneous bladder contractions and incontinence for voiding for UMN SCI. For males the urine collection is conducted with an external condom, tube, and bag. For females, collection is with an external vaginal collection cup and bag, or diapers [3,16]. Suprapubic tapping or stabbing is usually used to promote detrusor contractions and voiding. The five lower urinary tract conditions described above are associated with risks for RV. The combination of NDO and DSD results in low voiding efficiency and high PVR. This combination of conditions can also produce high detrusor pressure, which is a risk for ureteral reflux and kidney pathology. This risk to the kidney is the main reason RV is not recommended for urinary management [7,18]. A characteristic of NDU is short-duration detrusor contractions that contribute to high urinary retention and PVR [2,3]. We can also establish that UTI and AD are risks for RV. The dribbling of urine or the frequent voiding of small amounts are known risks. High detrusor pressures are a risk for AD and high blood pressure; also, in association with proximal-urethral smooth-muscle contractions the AD caused obstruction and increases PVR [2,3].

A bladder management program based on RV is not recommended due to its risks for the kidney, urinary retention, UTI, and AD [2,18]. SCI patients, however, may start using RV on their own. For instance, individuals with limited hand function find RV easier to

conduct than IC. Another example is patients using IC along with nighttime condom or pad collection of urine. These drainage methods can get extended into the day, and can result in a RV program. Urologists need to help these individuals have better RV outcomes. For management of DSD and improved RV outcomes following BT injections into the striated urethral sphincter, here are some suggestions.

### 3.1. DSD Management of Both the Striated Sphincter and Proximal Urethral Smooth Muscle

DSD is the most important condition to address for RV because it is associated with high leak point pressures (LPP), PVR, and ureteral reflux with risks for the kidney. Sphincterotomy in men with surgical cutting of the striated sphincter at the 12 o'clock position can be used to manage DSD; however, it is associated with surgical risks and continuing dysuria [5,6,9]. Poor outcomes from sphincterotomy have been associated with limited bladder contractile activity, high LPP and PVR. Extended sphincterotomy to include the prostate and bladder neck/proximal urethra can be used to address these concerns.

Botulinum toxin (BT) injection into the sphincter for RV is being used as an important alternative to sphincterotomy [25–27]. As these injections are noninvasive, it is particularly advocated to be used before sphincterotomy. The largest study of BT injection included 99 SCI patients, and the injection was conducted if DSD was found on urodynamic testing, and if the PVR was above 100 mL [25]. Both tetraplegia and paraplegia patients using RV were included. A transperineal approach was used to inject Botox (100 units), which was guided by electromyography and rectal palpation. Baseline assessment included video urodynamics for DSD, dysuria including UTI on a scale of 1 to 5, PVR, and a 48 h bladder diary. At one month, the outcome was deemed excellent when PVR was equal to or less than 100 mL and dysuria was 3 or less. There were significant reductions in PVR from 227 to 97 mL and the dysuria score decreased from 4.3 to 2.3. Effectiveness outcomes were found in 48% of patients and lasted 6.5 months. The need for IC was decreased or eliminated in 18 patients. Vesicoureteral reflux disappeared in some patients. A significant correlation was found between poor outcomes and smooth muscle/bladder neck DSDs as well as the absence of detrusor contractions during cystometry. Outcomes were also related to the severity of DSD prior to injection, and a strong correlation between PVR before and after injection. Injections were repeated in 36 patients and yielded similar outcomes in 89% of cases. Detrusor contractions and normal bladder neck activity were strong predictors of excellent outcome.

This study has helped to establish BT injections using the perineum approach [25]. Surprisingly, BT injection using cystoscopes have reported inferior outcomes; perhaps, because the injection is applied to a more limited area of tissue [26,27]. In addition, if high LPP and PVR remain after BT injections, sphincterotomy can be considered.

*Suggestion, simplified perineum BT injection:* an easier method for perineum BT injection is the use of only rectal guidance without electromyography [28]. We used this method for SCI patients having difficulties conducting IC, and they reported easier catheter passage indicating that the striated sphincter had been blocked (Table 2).

**Table 2.** Six problems and suggestions for RV and complete UMN SCI.

Problem	Suggestion
1. BT injection method	Use simpler rectal guidance for injection (Following BT injections to manage high PVR)
2 to 4. limited detrusor contraction & high PVR	Extended use of abdominal tapping/jabbing Use of urecholine 50 mg BID Future use of direct bladder wall stimulation
5. High rates of UTI	Urine egress concern and use of wireless TENS
6. Need for repeat BT injections	Sphincterotomy

There is a need to promote detrusor contractions for RV after BT injections to reduce PVR [25]. We gained insight into this need for promoting detrusor contractions by studying

these contractions and DSD in pilot SCI animal and clinical studies; studies that were conducted without the benefit of BT [29–31]. We compared DSD severity during urodynamics by recording detrusor pressure, pelvic floor electromyography, and anal sphincter pressure recording. We discovered that DSD was high during increasing detrusor pressure up to the peak pressure, however, during sustained peak pressures the DSD was greatly diminished. It was hypothesized that detrusor smooth-muscle movement was the primary contributor to stretch-receptor sensory activity, which through sacral spinal mechanisms produces DSD. Supporting this perspective, we observed that there is extensive movement of the smooth muscle during increasing detrusor pressures, but the movement was reduced or stopped during sustained peak pressures. Further, we observed that voiding for RV was primarily occurring during the sustained portion of detrusor contractions. Thus, we are making recommendations for inducing more sustained detrusor contractions.

*First suggestion, suprapubic tapping:* as introduced above, suprapubic tapping or stabbing is used with RV following BT injection to stimulate detrusor contractions for voiding [25,32]. Our research indicates that tapping is effective by increasing detrusor muscle movement, which stimulates sensory activity needed for reflex detrusor contractions. Thus, we suggest that performing more extended tapping/stabbing could produce longer detrusor contractions and reduce PVR (Table 2).

*Second suggestion, urecholine:* Urecholine is a detrusor stimulant, and we recommend 50 mg BID by mouth, which is a moderate dose with a low side-effect profile. This regimen has been proposed to help nonneurogenic patients to pass decatheterization tests following urological surgeries ([33], reviewed in this Special Issue of *Uro*). We recognize that the International Continence Society guideline states that Urecholine should not be prescribed in cases of nonobstructive urinary retention and an underactive bladder. The risk of the proposed Urecholine regimen, however, is low and the potential benefit for RV following BT injections is high; thus, we recommend testing this drug (Table 2).

*Third suggestion, direct bladder stimulation:* in clinical trials, direct bladder wall stimulation has been shown to produce voiding in SCI patients [34]; however, there are no current clinical trials of this method. We have also investigated direct bladder wall stimulation in animal models with modified electrodes [30,35,36]. Further research is needed, therefore, before this method can be offered to patients (Table 2).

As introduced above, there is a second type of DSD, smooth-muscle contraction of the bladder neck/proximal urethra, that is sympathetic in origin and that can reduce voiding and increase PVR [2,3]. Smooth muscle DSD should be suspected when increases in blood pressure occur during a detrusor contraction. Large increases in blood pressure indicates AD, which is associated with smooth-muscle DSD. This DSD can be diagnosed during cystourethrography as a lack of radiopaque medium in the proximal urethra during detrusor contractions. Importantly, AD is reduced by BT injections because voiding pressures are reduced [25,26]. In addition, surgical cutting of the bladder neck/proximal urethra can be conducted to manage bladder neck/proximal urethral contractions [6,7].

### 3.2. UTI and Dysuria Reduction for RV

BT injections lower the risk of UTIs, as reported above [25]. There is a need, however, to further reduce UTI burden. Also as introduced above, there is an unrecognized risk of urine egress. Elevated detrusor pressure can cause urine egress and elevated pressure is a common condition for RV. A problem with detrusor inhibition in a RV program is that the inhibitory treatment will undermine the detrusor contractions needed for voiding. With this limitation in mind, and as introduced above, wireless genital-nerve TENS for bladder inhibition could be considered (Table 2) [23]. In order to allow spontaneous detrusor contractions and voiding, the TENS would be stopped. In addition, this TENS intervention might allow for more control over the timing of voiding and, therefore, a more normal voiding program.

### 3.3. Concern about the Need for Repeat BT Injections

One limitation with BT injections for RV is that the injections must be repeated every 6 to 12 months [25,26]. If a more permanent DSD solution is needed, a sphincterotomy can be considered, as detailed above. (Table 2).

## 4. Management of Other Spinal Cord Injuries and Multiple Sclerosis

Incomplete UMN SCI occurs when the injury does not extend across the entire spinal cord. It is possible that patients suffering from this type of injury will have more awareness of bladder filling and voiding, and some may be able to use the toilet after an injury of this type. Nevertheless, their urological management is usually the same as described above for complete UMN SCI [2,3,7]. An incomplete SCI patient's bladder can be inhibited by sacral nerve neuromodulation with implanted electrodes early after injury, but not later after the injury [37]. An SCI of the sacral cord and sacral nerves is a lower motor neuron injury. These patients usually do not have NDO or DSD conditions, and they are more likely to have NDU with no bladder contractions. IC is the only treatment option for these patients since they have noncontractile bladders. Individuals with multiple sclerosis (MS) have similar lower urinary tract problems to SCI [2,3,7], and depending on the severity of MS, urological management is like SCI management.

## 5. Other Management Methods

Other bladder management methods are often used when IC and RV methods are insufficient. The alternate methods include indwelling Foley catheters, the Brindley implantable sacral ventral root stimulator, and urological surgeries for bladder augmentation and stomas [3,7,22]. A device that is expected to impact SCI urological care in the future is an intraurethral valve-pump catheter and activator, InFlow™ (inFlow™ urinary prosthesis; Vesiflow Inc, Washington) [38]. The device obtained recent regulatory approval in the United States for women with and without SCI [36]. A male device is in development. Outcome studies following SCI will establish the effectiveness of this device.

## 6. Conclusions

Bladder management following SCI is difficult because of the lower urinary tract conditions of DSD, NDO, NDU, AD and UTI. For IC management, incontinence between catheterizations can be prevented with bladder inhibitory interventions. Studies on QoL have, however, demonstrated that patients using IC continue to suffer from dysuria and completing the many catheterizations. We provided three suggestions for improving IC care including the use of low friction catheters, wireless genital-nerve TENS for bladder inhibition, and the need for the diagnosis and treatment of urine egress as a risk factor for UTI.

Despite the fact that RV bladder management is not recommended for SCI patients, some patients choose to use this method because it is easier to conduct than IC or because they have limited hand function. These patients should be well informed about the risks of RV. BT injection into the striated sphincter through a perineum approach is a recommended treatment for DSD. We provided six suggestions to improve RV outcomes following BT injections. A BT injection method of using only rectal guidance is suggested. We make three suggestions to promote longer detrusor contractions to reduce PVR. These include prolonged abdominal tapping or jabbing, urecholine 50 mg BID, and direct bladder wall stimulation (as a future intervention). We suggest the consideration of urine egress as an unrecognized risk factor for UTI; also a role for genital-nerve wireless TENS for egress management and better control of the time for voiding. If the lower urinary tract problems persist after BT injections, consider of a sphincterotomy can be conducted.

Briefly discussed are IC and RV programs for individuals with incomplete spinal injuries, lower motor neuron injuries and multiple sclerosis. Alternative management methods are also mentioned.

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### Abbreviations

Spinal cord injury, SCI; upper motor neuron, UMN; neurogenic detrusor overactivity, NDO; neurogenic detrusor underactivity, NDU; detrusor sphincter dyssynergia DSD; leak point pressure LPP; autonomic dysreflexia AD; urinary tract infections UTI; intermittent catheterization IC; detrusor muscarinic receptor antagonists MRA; post-void residual volume, PVR; botulinum toxin, BT; reflex voiding, RV, transcutaneous electrical nerve stimulation, TENS; quality of Live, QoL.

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