Canadian Urological Association guideline: Diagnosis, management, and surveillance of neurogenic lower urinary tract dysfunction – Executive summary

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Introduction

Definitions/purpose

The term "neurogenic bladder" describes lower urinary tract dysfunction that has occurred likely as a result of a neurological injury or disease.[1] The International Continence Society (ICS) defines "neurogenic lower urinary tract dysfunction" (NLUTD) as "lower urinary tract dysfunction due to disturbance of the neurologic control mechanism." This broad definition is used to describe a multitude of conditions of varying severity.

Common causes of NLUTD include: spinal cord injury (SCI), multiple sclerosis (MS), and myelomeningocele (MMC). Other causes of NLUTD include: Parkinson's disease, cerebrovascular accidents, traumatic brain injury, brain or spinal cord tumour, cauda equina syndrome, transverse myelitis, multisystem atrophy, pelvic nerve injury, and diabetes.

It is well-described that neurological disorders can lead to urological complications, including: urinary incontinence, urinary tract infection (UTI), urolithiasis, sepsis, ureteric obstruction, vesicoureteric reflux (VUR), and renal failure.[2] Due to the potential morbidity, and even mortality, initial investigation, ongoing management, and surveillance is warranted in this patient population. Despite the frequency and potential severity of NLUTD, there are few high-quality studies in the literature to guide urological practices.

Prior neurogenic guidelines vary in their clinical assessment, investigations used, and surveillance strategies.[2-6] The primary reason is that there is limited evidence to support a common strategy. The purpose of this guideline is to help urologists to identify high-risk patients with NLUTD and to provide an approach to the management and surveillance of patients with NLUTD.

Classification

The etiology of a NLUTD is often classified based on whether the primary lesion is suprapontine, suprasacral, sacral, or infrasacral.[7] A complementary system was developed by Madersbacher et al based on the function of the detrusor muscle and of the external sphincter.[8] These systems allow a physician to have a general idea of how the lower urinary tract is likely to behave in SCI patients with more complete injuries (Fig. 1). Newer systems using magnetic resonance (MR) urography in combination with urodynamics (UDS) have also been proposed.[9]

Methodology

This review was performed according to the methodology recommended by the Canadian Urological Association.[10] EmBASE and Medline databases were used to identify literature relevant to the early urological care of NLUTD patients. Recommendations were developed by consensus among the authors and graded using a modified Oxford system, which identifies level of evidence (LOE) and grade of recommendation (GOR). For brevity, a complete version is included online (available at cuaj.ca); this executive summary focuses on recommendations from specific sections and the initial evaluation and surveillance for patients with NLUTD.

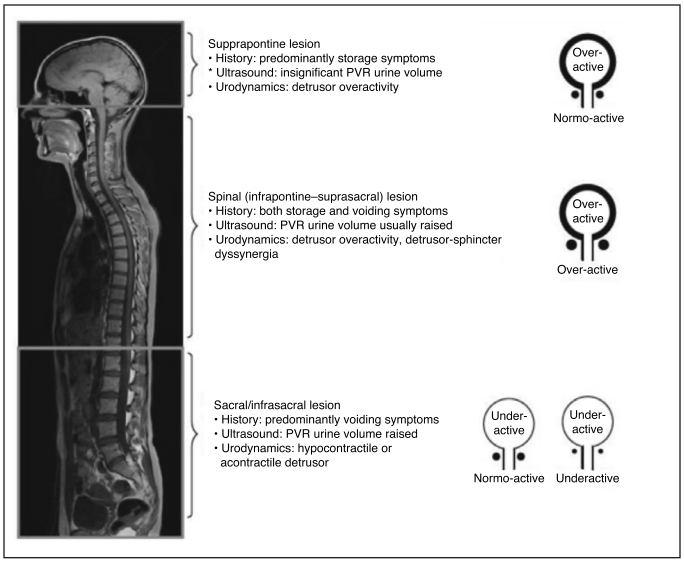

Fig. 1. Classification of lower urinary tract dysfunction based on level of lesion (adapted from Panicker et al[7]).

Canadian epidemiology of NLUTD

This is included in the complete online reference (available at *cuaj.ca*)

The diagnosis of NLUTD

To diagnose someone with NLUTD, a defined neurological condition or a strong suspicion of an undiagnosed neurological disease must be present. Potential symptoms that may be suggestive of an undiagnosed acquired neurological disease include those that precede a diagnosis of MS, cauda equina syndrome, and occult neural tube defect.[7] In these situations, referral to a neurologist for an evaluation may be warranted.

History and physical exam

In the setting of a diagnosed or probable neurological disease, a careful evaluation must be carried out to identify symptoms and signs associated with NLUTD, with an emphasis on identifying common and potentially serious complications. In most cases, investigations followed by appropriate management can minimize this morbidity. The general approach to the clinical history specifically relevant to a patient with NLUTD is shown in Table 1.

The timing of this initial evaluation is variable and dependent on the severity of symptoms, underlying risk of serious urological complications, and the etiology of the NLUTD. Spina bifida[11] and SCI[12] have a significant risk of renal dysfunction and are acquired at birth (spina bifida) or often as young adults (SCI); this makes patients particularly susceptible to renal dysfunction in their lifetime. This contrasts with slowly progressive diseases, such as relapsing-remitting MS, or the predominately elderly population with Parkinson's disease or dementia.

The urological evaluation of a patient with a newly acquired SCI should occur within 3–6 months of the SCI. Efforts should made to assess patients with urological complications or concerns as soon as possible after the acute SCI. Recent evidence has demonstrated that significant bladder dysfunction can appear early after SCI.[13] Even ambulatory patients who have experienced a SCI can exhibit significant and often asymptomatic bladder dysfunction when evaluated with UDS.[14] Many patients with MS do not need specialized investigation of their bladder during the initial years after diag-

Table 1. Elements of a focused neuro-urological history should be tailored to the disease

	Examples:
History of the neurological disease	SCI: Year and level/completeness of lesion (ASIA level), frequency of autonomic dysreflexia, level of spasticity, mobility/transfers
	MS: Year and type of MS (primary progressive, secondary progressive, relapsing remitting), mobility level (or Expanded Disability Status Scale)
	Spinal bifida: Type (i.e., ambulatory lipomyelomeningocele), caregiver, VP shunt, latex allergy, prior reconstructive surgery
Bladder management history	Use of catheters (CIC, indwelling [size and frequency of changes], condom), crede/straining/reflexive bladder emptying, bladder medications, and prior urological surgery history
Storage symptoms & voiding symptoms	Frequency, urgency, nocturia, incontinence Weak stream, intermittency, straining, incomplete emptying
General components	Allergies, medications, alcohol/drug use/smoking
NLUTD complications	UTIs (symptoms, culture status, associated sepsis/fever, response to antibiotics/antibiotic resistance, triggers, hospital admissions)
	Sequela of incontinence (skin breakdown, ulcers, pad usage, bother)
	Bladder or renal stone disease
	Catheter complications (urethral loss in women; urethral erosion, false passages, strictures in men, encrustation/sediment)
	Renal function (imaging results, renal function)
Review of relevant systems	Bowel function Sexual function Coexisting non-NLUTD dysfunction (prostatic enlargement, stress incontinence) Gross hematuria Gynecological/pregnancy history Genitourinary/pelvic pain Motor abilities (hand function, ability to transfer) Cognitive function Support systems/caregivers

CIC: clean intermittent catheterization; MS: multiple sclerosis; NLUTD: neurogenic lower urinary tract dysfunction; SCI: spinal cord injury; UTI: urinary tract infection.

Table 2. Indicators of NLUTD patient characteristics potentially at higher risk of urological morbidity

	High-risk diagnoses/features
Etiology of neurogenic bladder	SCI, spina bifida, advanced MS
Bladder management method	Valsalva/crede/reflexive bladder emptying, indwelling catheter SCI patients with autonomic dysreflexia associated with bladder function
Urodynamics	DSD, NDO*, impaired compliance (<20 mL/cmH_2O), DLPP >40 cmH_2O), vesico-ureteral reflux
Renal-bladder imaging	New-onset/worsening hydronephrosis, stone disease, renal atrophy/scarring Abnormal bladder morphology
Renal function	New-onset/worsening renal insufficiency

*The exact characteristics of NDO that are most concerning for renal dysfunction are not clearly defined. High-risk NDO should be interpreted based on the volume at onset, duration, peak pressure, and associated incontinence. These urodynamic findings should be interpreted in the context of the normal voiding habits of the patient. DLPP: detrusor leak point pressure; DSD: detrusor-sphincter dyssynergia; MS: multiple sclerosis; NDO: neurogenic detrusor overactivity; NLUTD: neurogenic lower urinary tract dysfunction; SCI: spinal cord injury.

nosis. With progression of MS, the risk of bladder dysfunction increases as mobility and functional status decreases, and urological assessment may become more relevant.[15,16] When children with spina bifida transition to adulthood, they should be followed by an adult urologist as soon as it is practical to transition them.[17] Ideally, transition to an adult care provider should involve more than a referral; a summary of childhood procedures, up-to-date baseline investigations, and a period of overlapping care may be beneficial.[18]

Voiding diaries should be considered for all patients.[19] They allow the patient to self-reflect on their urinary habits and the physician to measure changes over time in a non-invasive manner and interpret urodynamic findings in the context of the patient's day-to-day urinary patterns. Validated questionnaires are an optional adjunct to the assessment of NLUTD patients; they are generally used for research purposes in this population.[20]

The specific physical exam to be carried out on patients with NLUTD should include an assessment of body habitus with an abdominal, genital, and rectal exam.[7] It may, in certain circumstances, include a focused screening neurological exam (such as lower limb sensory, motor and reflex function), especially when there is a suspicion of NLUTD without a confirmed neurological disease.

Investigations

Office-based

The initial investigations that should be performed for all NLUTD patients include urine dip (to investigate for infection, microscopic hematuria, and unexpected pyuria or proteinuria), and post-void residual (PVR) volume measurement. Urine dip may need to be followed by a urine microscopy and must be interpreted in the context of catheter usage. In patients who are voiding spontaneously, using reflexive voiding/crede emptying, or using a condom catheter, the detection of an elevated PVR is important to address potential UTI risk and overflow incontinence and may prompt screening for upper tract deterioration. It is important to recognize that a PVR at the time of renal ultrasound may be artificially elevated secondary to the hydration protocol resulting in bladder over-distension; an elevated PVR from a renal ultrasound should be confirmed in a more normal setting.

PVR is not clearly defined as a factor associated with increased risk of complications among patients with NLUTD.[21] In the non-NLUDT population, a value >300 mL is used to define chronic urinary retention.[22] In NLUTD patients with a PVR >300 mL, it is reasonable to follow them for a period of time to determine the stability of their PVR and bladder symptoms. PVR needs to be interpreted based on the proportion of urine voided and method of bladder emptying. The need to treat PVR should be based on patient symptoms rather than an absolute number.

Specific patient populations require further investigation due to a higher risk of serious sequela from bladder dysfunction. The first evaluation of a patient with spina bifida, SCI, or a patient with more advanced MS should include UDS, renal-bladder imaging, and a measurement of renal function.

Urodynamics (UDS)

They are the gold standard for evaluating NLUTD and are necessary due to the absence of normal lower urinary tract sensation and the poor ability of symptoms to predict high-risk features. VideoUDS are preferred, as the additional correlation with imaging allows assessment of VUR, abnormal bladder morphology, and the behaviour of the urinary sphincters during voiding. The availability of videoUDS is not universal, and a voiding cystogram is an acceptable alternative in some cases. Urodynamic diagnoses, such as neurogenic detrusor overactivity (NDO), impaired compliance, reduced bladder capacity, or a high detrusor leak point pressure (DLPP, defined as the lowest vesical pressure at which urine leaks from the bladder in the absence of a detrusor contraction or increased abdominal straining), can identify a patient with potentially higher risk of urological complications (such as renal dysfunction, UTIs, and incontinence).[23-26] Other potential urodynamic characteristics, such as the duration of the NDO contraction, may also predict renal deterioration.[27] A DLPP of >40 cmH_2O has traditionally been cited as the cutoff above which a patient has a high risk of renal deterioration, however, this is based on a historical study of children with spina bifida, and may not be applicable to adult NLUTD. As DLPP increases, so too does the risk of renal dysfunction due to an increased resting pressure in the bladder being transmitted to the kidneys. If a high DLPP only occurs at a volume greater than the

usual capacity during the normal daily voiding pattern, then this DLPP may not be physiologically relevant. A low DLPP maintains low pressure drainage from the kidneys, however, this often results in urinary incontinence.

Imaging

Renal and bladder imaging is necessary to identify hydronephrosis (a late but potentially reversible sign of bladder dysfunction in NLUTD), renal/bladder stone disease, abnormal bladder morphology (for example, thickened bladder wall, diverticula), and both renal atrophy and degree of scarring; both SCI and spina bifida patients are at an increased risk of renal stone disease, and this may present with atypical symptoms (such as nausea or decreased appetite).[28-30] Often bladder stones are asymptomatic and early treatment, while they are amendable to endoscopic management, is preferable.

Renal function

Patients with SCI and spina bifida are at increased risk of renal dysfunction; a serum creatinine can be used to assess renal function, however, it may not accurately reflect renal function in these two populations.[16] Evaluating the creatinine in the context of previous readings is potentially useful, although it is important to note that changes within the normal range may still be significant. Either a nuclear medicine glomerular filtration rate (GFR) or a 24-hour urine collection for creatinine clearance will better reflect renal function and allow the identification of early renal dysfunction. While renal dysfunction secondary to bladder dysfunction can occur with MS, it is quite uncommon (estimated at 0.5%).[31]

Cystoscopy

This should be reserved for situations where there is a clinical indication to assess either the urethra or bladder (such as suspicion of urethral strictures or false passages, bladder stones, or bladder cancer). Screening cystoscopy has historically been recommended among patients with indwelling catheters or after SCI, however, there is no evidence that screening programs are effective.[32] Cystoscopy has a poor sensitivity for bladder cancer in SCI patients; the higher-risk cancers after SCI are rarely detected at an early enough stage, which would affect their natural history, and there is very poor real-world compliance with cystoscopy screening programs. However, there does seem to be an increased risk of bladder cancer in patients after SCI, potentially as a result of indwelling catheter usage, and cystoscopy should be used when there is suspicion of a bladder tumour.[32] Patients with NLUTD and bladder cancer may present late due to hematuria being attributed to catheter usage and atypical presentations, such as frequent UTIs, urethral discharge, or abdominal mass.

Summary

The initial history, physical exam, and investigations serve to identify high-risk features in patients with SCI, spina bifida, or more advanced MS patients (Table 2). Assignment of risk is based on relevant abnormalities within one of five domains; two are determined from the patient history (etiology of NLUTD and bladder management) and three are determined based on the initial investigations (UDS, renal imaging, and renal function).

Among patients with NLUTD due to other etiologies (or early stage MS), the majority can be managed with history, physical exam, urinalysis, and PVR (Fig. 2). The subset of these patients with a clinically significant PVR, bothersome incontinence, frequent UTIs, need for catheters as part of their bladder management, known high-risk features on UDS, renal imaging, and renal function testing, or those considering more invasive management options may require UDS, renal-bladder imaging, and renal function measurement.

Recommendations

- **When referred a new patient with NLUTD, a focused history and physical exam, relevant to the neurogenic condition, should be performed** *(GOR A, LOE expert opinion)*.
- **All patients with NLUTD should have a urinalysis and PVR as part of their initial evaluation** *(GOR B, LOE 3)*.
- **After a SCI, patients should have a baseline urological assessment within six months of SCI, or earlier if clinical concerns exist** *(GOR A, LOE 2)*.
- **Patients with SCI, spina bifida, or advanced MS should have a baseline UDS, renal ultrasound, and measurement of renal function. Selected patients with NLUTD due to other diagnoses may undergo these investigations when referred for specific urological concerns** *(GOR A, LOE 3)*.
- **The treating clinician should identify patients as either being high-, moderate-, or low-risk, and offer the patient appropriate initial therapy, and consider a urological surveillance program as outlined below** *(GOR B, LOE 3)*.

Genitourinary sequelae of NLUTD: Upper tract deterioration, incontinence and urethral damage, and urinary tract infections

This is included in the complete online reference (available at *cuaj.ca*). In summary,

- **Among SCI patients, voiding by reflex triggering, Valsalva or Credé manoeuvres should be strongly dis-**

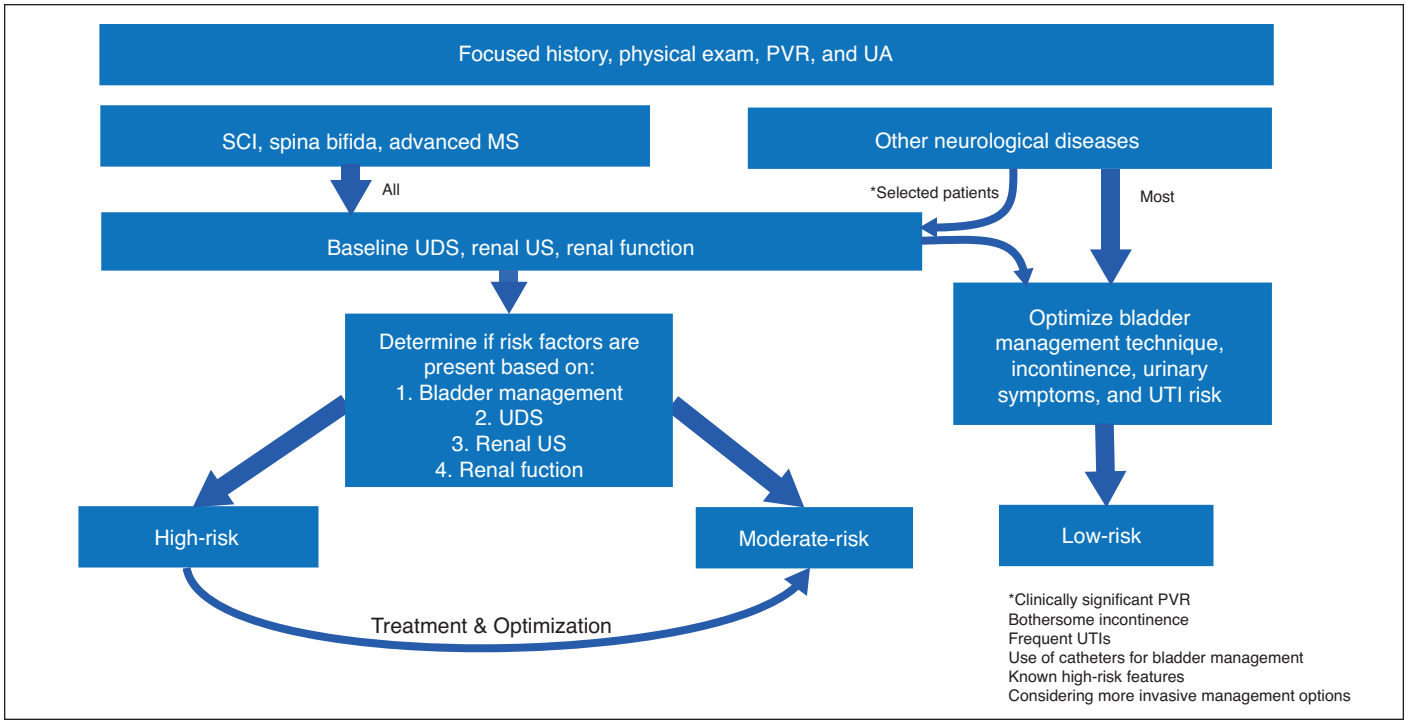

Fig. 2. Initial investigations and risk stratification for neurogenic lower urinary tract dysfunction (NLUTD) patients. High-risk patients are considered those with spinal cord injury (SCI), spina bifida, advanced multiple sclerosis (MS), or select other neurogenic diseases with evidence of significant urological complications or morbidity in addition to: 1) bladder management technique: Valsalva/crede/reflexive voiding; or 2) known high-risk features on urodynamics (UDS) without confirmation of appropriate attenuation after treatment (detrusor-sphincter dyssynergia [DSD], neurogenic detrusor overactivity [NDO], impaired compliance (<20 ml/cmH_2O), detrusor leak point pressure [DLPP] >40 cmH_2O, vesico-ureteral reflex); or 3) new/worsening renal imaging (hydronephrosis, atrophy, scarring); or 4) new/worsening renal insufficiency. Patients with SCI, spina bifida, or advanced MS without high-risk features are considered moderate-risk. PVR: post-void residual; UA: urinalysis; US: ultrasound; UTI: urinary tract infection.

couraged in most patients due the potential risk of renal deterioration *(GOR B, LOE 3)*.

- **Patients with indwelling urethral catheters should be offered conversion to a suprapubic catheter in the setting of significant urethral damage** *(GOR A, LOE 3)*.
- **In NLUTD, a UTI is defined as bacteriuria with an appropriate colony count for the source of the urinary sample, evidence of pyuria, and relevant signs/symptoms (such as fever, urinary incontinence/failure of control or leaking around catheter, increased spasticity, malaise, lethargy or sense of unease, cloudy urine, malodorous urine, back pain, bladder pain, dysuria, and autonomic dysreflexia). Cloudy or malodorous urine should not be relied on in isolation to identify a clinically relevant UTI** *(GOR A, LOE 3)*.
- **Numerous studies clearly demonstrate that screening and treatment of asymptomatic bacteriuria in persons with NLUTD should be avoided (aside from pregnancy and prior to certain urological interventions), as it promotes microbe resistance and can increase the likelihood of symptomatic UTI** *(GOR A, LOE 2)*.
- **Urine cultures should always be obtained prior to antimicrobial therapy due to the increased risk of nosocomial and multidrug-resistant microorganisms** *(GOR A, LOE 2)*.
- **A seven-day course of antimicrobials is recommended for NLUTD patients with a UTI and a prompt clinical response; 10–14 days of therapy should be used for those with significant infection or a delayed response** *(GOR A, LOE 3)*.
- **When possible, clean intermittent catheterization (CIC) should be used over other types of catheters to minimize UTI risk** *(GOR A, LOE 2)*.
- **Routine antimicrobial prophylaxis for NLUTD UTI is not recommended for most patients** *(GOR A, LOE I)*.

Treatment of NLUTD

Assisted bladder drainage

This is included in the complete online reference (available at *cuaj.ca*). In summary,

- **Selection of an assisted bladder drainage method (CIC, urethral or suprapubic catheter) should be individualized to the patient's motor functions, anatomic limitations, bladder characteristics, prior urological complications, and quality of life** *(GOR A, LOE 3)*.

Oral and transcutaneous medical therapy

Treatment of NLUTD aims to lower detrusor storage pressure and increase bladder capacity in order to protect upper tract function and to decrease urinary incontinence.

Anticholinergics

A meta-analysis in NDO reviewed all randomized controlled trials (RCTs) between 1966 and 2011 (total 960 patients). They demonstrated that anticholinergic administration in this population was associated with statistically significant differences in patient-reported cure/improvement, bladder capacity, and detrusor pressure compared to placebo. Studies that compared one medication to another (usually oxybutynin IR), did not reveal statistically significant differences. The optimal drug dosage was not identified.[33] Madersbacher et al extended their review to include other non-RCT studies and found an approximate decrease of 30–40% in maximal detrusor pressures and an increase of maximum cystometric bladder capacity of 30–40% for oxybutynin IR, propiverine IR, propiverine ER, and trospium chloride IR compared to placebo.[34] **Antimuscarinics should, therefore, be offered to people with urodynamic findings of NDO or those with SCI and symptoms of overactive bladder (OAB)** *(GOR A, LOE 1a)*. The preferential drug of choice should be individualized, but evidence for efficacy exists for oxybutynin IR and ER, tolterodine IR and ER, propiverine IR, darifenacin, and solifenacin. Antimuscarinic dosage should be escalated to optimize improvement of symptoms or urodynamic parameters, as tolerated by the patient, with the possibility of increasing adverse events. Supratherapeutic dosages may be considered according to tolerability, but should be used cautiously.[35] Combining antimuscarinics may be beneficial for patients who are refractory to dose escalation antimuscarinic monotherapy[36,37] and is suggested by the European Association of Urology (EAU) guidelines.[38]

The administration of antimuscarinics should be considered whether or not patients are using assisted bladder drainage *(GOR C, LOE 4)*. The absence of its usage has been shown to be a risk factor for upper tract deterioration.[39] If the bladder is being drained, there is less of a concern of elevated PVR. In patients with indwelling catheters, oxybutynin use was associated with less risk of hydronephrosis and should be considered.[40]

B3 adrenergic agonist therapy

There is limited evidence for the use of mirabegron for the treatment of NDO or NLUTD. A retrospective review found an improvement in urodynamic parameters in 15 patients with NDO on mirabegron.[41] There are currently trials underway to assess its efficacy in this patient population.[42] **Mirabegron may be a useful alternative to anticholinergics for patients with symptoms of OAB and NLUTD, but further evidence of urodynamic changes are needed in this population** *(GOR C, LOE 4)*.

Recommendations

- **Oral antimuscarinics with dose escalation are the first-line pharmacological treatment for patients with NLUTD in order to improve OAB symptoms and NDO, decrease urgency urinary incontinence, and lower detrusor pressures** *(GOR A, LOE 1a)*.
- **There is very limited data supporting the use of transdermal oxybutynin or mirabegron in NLUTD** *(GOR C, LOE 4)*.

Intravesical therapy

OnabotulinumtoxinA (Botox®) intradetrusor injection has been proven to be an effective and safe long-term therapy for the management of NLUTD secondary to SCI or MS. **Results of powered, placebo-controlled, multicentre, phase 3 RCTs and meta-analysis demonstrated clinically significant outcomes and sustained efficacy in terms of reduced incontinence episodes, enhanced bladder function, as well as substantial improvements in key urodynamic parameters and quality of life[43-47]** *(GOR A, LOE 1a)*. **Achieved therapeutic effects are comparable between both onabotulinumtoxinA doses (200 units and 300 units) in terms of efficacy and durability, but catheter initiation rates were dose-dependent[44,48]** *(GOR B, LOE 1b)*. The standard recommended dose by Health Canada with more favourable safety profile is 200 units.[49] **Safety assessments identified**

Recommendations

- **OnabotulinumtoxinA injection (200 units) in the detrusor is an effective, minimally invasive treatment that can achieve continence, improve bladder function, and diminish NDO in individuals with SCI or MS who have an inadequate response to or are intolerant of an anticholinergic medication** *(GOR A, LOE 1)*.
- **AbobotulinumtoxinA is also efficacious in NLUTD, with the optimal dose of 750 units** *(GOR B, LOE 1b)*.
- **Intravesical oxybutynin is a safe alternative approach to managing NDO and NLUTD in patients who are doing CIC** *(GOR B, LOE 2)*.

UTIs and large urine residual or urinary retention as the most frequent adverse events. These findings are more predominant among 300 units groups and patients not using CIC at baseline. Therefore, the likelihood of future need of CIC is increased.[44,46,48] *(GOR A, LOE 1b)*. Muscle weakness and respiratory problems are other serious complications that are rarely reported.[44,48,50]

Neural stimulation and neuromodulation therapy

This is included in the complete online reference (available at *cuaj.ca*). In summary,

- **Dorsal rhizotomy (sacral deafferentation S2-S4/5) and sacral anterior root stimulation (SARS) can achieve safe storage detrusor pressure and voluntary emptying of bladder and bowel in patients with complete SCI, but comes with long-term complication rate and a very high rate of surgical revisions** *(GOR C, LOE 3)*.
- **Percutaneous tibial nerve stimuation may improve urodynamic and clinical outcomes in NLUTD with minimal reported adverse events** *(GOR C, LOE 4)*.

Surgical management of LUTD

This is included in the complete online reference (available at *cuaj.ca*). In summary,

- **Bladder augmentation (preferably with ileal cystoplasty) is indicated in cases of reduced compliance or NDO refractory to all other non-surgical treatments, or reduced bladder capacity necessitating an indwelling catheter or CIC to be done too frequently** *(GOR B, LOE 2)*.

Surveillance studies for NLUTD patients in the community setting

After initial assessment and treatment to optimize bladder function, NLUTD patients are followed with regular clinical assessment and, in some cases, surveillance investigations. NLUTD surveillance is stratified based on the risk of NLUTD sequelae. Although it is suggested that clinical examination alone is not sufficient to determine individual urological management strategies in patients with NLUTD,[51] data demonstrating the value of surveillance investigations in the setting of NLUTD is lacking.[52] Similarly, urodynamic risk-stratification has been suggested based on high-pressure storage and voiding features, but characterization of overall risk groups for NLUTD sequelae remains largely undefined to date.[53-55] Typically, surveillance protocols suggest either on-demand or regularly scheduled UDS, upper tract imaging, and cystoscopy but there is little consensus on specific approach[3-5,56] Consequently, practice patterns vary with regard to the type and frequency of studies used in NLUTD surveillance.[56-59] Our suggested approach for NLUTD stratifies patients based on their urological risk factors and specific investigations are recommended.

Surveillance clinical assessment

The primary goal of clinical assessment is to stratify patients based on their risk of NLUTD sequelae. Patients deemed low-risk are followed with a simple clinical assessment, while those deemed higher-risk undergo a more detailed evaluation of the urinary tract function and anatomy. Depending on the specific risk factors involved, this may include urodynamic evaluation, renal-bladder imaging, and renal function assessment. The detailed evaluation of the higher-risk groups is intended to address modifiable factors that may allow the patient to be reclassified as a lower-risk patient. Relevant findings on history include bladder management technique (particularly high-risk groups, including condom drainage, Valsalva/crede/reflexive bladder-emptying), incontinence pattern, UTI profile, autonomic dysreflexia, and most recent urodynamic evaluation and upper tract imaging. **We recommend regular yearly clinical assessment of all NLUTD patients with their physiatrist, neurologist, or general practitioner; we recommend that a urologist is involved in the assessment of patients who are in the moderate- or high-risk categories (for example, SCI, spina bifida, advanced MS), as described in Table 3** *(GOR C, LOE 4)*.

Surveillance investigations

Imaging

Routine surveillance imaging provides interval evaluation of the anatomy of the urinary tract and characterizes hydronephrosis, renal atrophy, scars, urinary stones, diverticula, trabeculation, large bladder lesions, and quantifies PVR. A recent systematic review concluded that there is sufficient evidence to recommend yearly ultrasound of the kidneys and urinary tract as a useful, cost-effective, non-invasive method for routine long-term followup to detect upper urinary tract problems in all individuals with SCI. Although the findings have been applied to other underlying pathologies within NLUTD, the benefit has not been quantified.[28] **We suggest yearly renal and bladder ultrasound in high- and moderate-risk NLUTD patients (for example, SCI, spina bifida, advanced MS), as described in Table 3** *(GOR C, LOE 4)*.

Cystoscopy

While historically used for concerns of increased bladder cancer risk, cystoscopy can be a valuable tool in the evaluation of urethral or bladder integrity and can provide an estimate of external sphincter function. The value of surveil-

Table 3. Surveillance strategy for neurogenic lower urinary tract dysfunction (NLUTD) based on patient risk-stratification

Risk group	Description	Suggested surveillance strategy
High-risk	Underlying high-risk disease (SCI, spina bifida, advanced MS) or select other neurogenic diseases with evidence of significant urological complications or morbidity) in addition to: – Bladder management technique: Valsalva/crede/reflexive voiding; or – Known high-risk features on UDS without confirmation of appropriate attenuation after treatment (DSD, NDO, impaired compliance [<20 ml/cmH_2O], DLPP >40 cmH_2O, vesico-ureteral reflex); or – New/worsening renal imaging (hydronephrosis, atrophy, scarring); or – New/worsening renal insufficiency	– Yearly urological evaluation (history and physical examination) – Yearly UDS – Yearly renal-bladder imaging – Yearly renal function assessment
Moderate-risk	Underlying high-risk disease (SCI, spina bifida, advanced MS) or select other neurogenic diseases with evidence of significant urological complications or morbidity) in addition to: – Bladder management technique: CIC, spontaneous voiding, indwelling catheter – Prior history of high-risk features on UDS that have been appropriately optimized (DSD, NDO, impaired compliance [<20 mL/cmH_2O], DLPP >40 cmH_2O, vesico-ureteral reflex); or – Renal imaging without any significant interval change; or – Renal function without any significant interval change	– Yearly urological evaluation (history and physical examination) – Yearly renal-bladder imaging – Periodic UDS (every 2–5 years) – Yearly renal function assessment
Low-risk	No evidence of high-risk disease and no features on initial evaluation that would be considered high-risk	– Yearly evaluation with GP, physiatrist, neurologist, or urologist (history and physical examination with attention to general neuro-urological assessment outlined previously) – Yearly renal imaging in select cases – Re-referral for urological evaluation as suggested by: • New-onset/worsening incontinence; or • New frequent urinary infections; or • New-onset catheter issues (for example, penile/urethral erosions, encrustation, bypassing) • Renal-bladder imaging changes suggestive of upper or lower UT deterioration (hydronephrosis, new clinically significant PVR, or significant increase in PVR) or new stone disease

DLPP: detrusor leak point pressure; DSD: detrusor-sphincter dyssynergia; GP: general practitioner; MS: multiple sclerosis; NDO: neurogenic detrusor overactivity; PVR: post-void residual; SCI: spinal cord injury; UDS: urodynamic study; UT: urinary tract.

lance cystoscopy for bladder cancer surveillance in the SCI population was addressed in a recent systematic review by Cameron et al.[57] The investigators believed that the incidence of bladder cancer was too low to be well-evaluated in these studies, and screening cystoscopy and biopsy did not fit the criteria for a screening test of the general NLUTD population. Patients with prior augmentation cystoplasty have historically been followed with yearly surveillance cystoscopy due to increased risk of bladder cancer.[60] Recent studies demonstrate no benefit from surveillance cystoscopy in the augmented population.[61-63] **We support the use of cystoscopy for the assessment of suspected urethral or bladder pathology. We do not support routine surveillance cystoscopy for bladder cancer screening in NLUTD with or without augmentation cystoplasty** *(GOR C, LOE 4)*.

UDS

Attempts at establishing a risk vs. benefit ratio for regularly scheduled surveillance UDS are limited by heterogeneous populations and varying surveillance strategies. Some authors demonstrate benefit of regularly scheduled yearly urodynamic evaluation.[64,65] Conversely, others establish a safe lower urinary tract with baseline UDS, and subsequently perform annual renal ultrasonography for surveillance. UDS in this strategy is repeated only when patients presented with changing incontinence patterns or alarming radiological changes.[66] Existing guidelines have little consensus on the specific strategy of implementation and high enrollment studies are not currently available. **We support the use of surveillance UDS in moderate-risk patients every 2–5 years and high-risk patients every year** *(GOR C, LOE 4)*. **VideoUDS or a cystogram should be performed in patients where further knowledge of the urinary tract anatomy is needed.**

Proposed surveillance strategy

There is a lack of evidence to establish any clear strategy of surveillance for NLUTD, as evidenced by the varying recommendations of numerous prior guidelines[3-5,56] The primary goals of surveillance screening studies are to mitigate NLUTD sequelae and we propose a strategy based on risk-stratification. **Our proposed surveillance strategy is included in Table 3. The integrity of this strategy has not been verified empirically; it represents the consensus opinion of our contributors** *(GOR C, LOE 4)*.

Competing interests: Dr. Kavanagh has been an advisory board member for Paladin Labs, and has received a research grant from Astellas. Dr. Baverstock has been a speaker for Allergan, Astellas, BSCI, and Pfizer; and has participated in clinical trials supported by Astellas and Pfizer. Dr. Campeau has been an advisory board and speaker bureau member for Asetllas and Pfizer; has received grants/honoraria from Allergan, Astellas, and Pfizer; and has participated in clinical trials supported by Pfizer. Dr. Cox has been an advisory board member for Pfizer; a speakers bureau member for Astellas and Pfizer; has received grants/honoraria from Astellas and Pfizer; and has participated in clinical trials supported by Aquinox. Dr. Hickling has been an advisory board member for Pfizer; a speakers bureau member for Allergan, Astellas and Pfizer; has received grants/honoraria from Allergan, Astellas and Pfizer; and has participated in clinical trials supported by Astellas. Dr. Nadeau has been an advisory board member for Allergan, AMS, Astellas, Boston Scientific, Ferring, and Pfizer; a speakers bureau member for, Allergan, Astellas, Ferring Laborie, and Pfizer; and and has participated in clinical trials supported by Astellas. The remaining authors report no competing personal or financial interests related to this work.

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