Guidelines on Neurogenic Lower Urinary Tract Dysfunction

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1. BACKGROUND

1.1 Aims and objectives

The purpose of these clinical guidelines is to provide useful information for clinical practitioners on the incidence, definitions, diagnosis, therapy, and follow-up observation of the condition of neurogenic lower urinary tract dysfunction (NLUTD). These guidelines reflect the current opinion of the experts in this specific pathology and thus represent a state-of-the-art reference for all clinicians, as of the date of its presentation to the European Association of Urology (EAU).

The EAU Guidelines panel consists of an international multidisciplinary group of experts, including urologists specialised in the care of spinal cord injured (SCI) patients, as well as a specialist in the field of urodynamic technologies.

The terminology used and the diagnostic procedures advised throughout these guidelines follow the recommendations for investigations on the lower urinary tract (LUT) as published by the International Continence Society (ICS) (1-3).

1.2 Methodology

*1.2.1 **Data identification***

Literature searches were carried out for all sections of the Neurogenic Lower Urinary Tract Dysfunction guidelines. Focus of all searches was identification of all level 1 scientific papers (systematic reviews and meta-analyses of randomised controlled trials) in accordance with EAU methodology. In case sufficient data was identified to answer the clinical question, the search was not expanded to include lower level literature. The search was limited to English language publications, animal studies were excluded. Additionally, the guidelines panel have included scientific material from foreign language publications and textbooks.

*1.2.2 **Evidence sources***

Searches were carried out in Medline and Embase on the Dialog-Datastar platform. The searches used the controlled terminology of the respective databases. Both MesH and EMTREE were analysed for relevant terms. In many cases the use of free text ensured the sensitivity of the searches.

Randomised controlled trial (RCT) strategies used were based on Scottish Intercollegiate Guidelines Network (SIGN) and Modified McMaster/Health Information Research Unit (HIRU) filters for RCTs, systematic reviews and practice guidelines on the OVID platform and then translated into Datastar syntax.

*1.2.3 **Level of evidence and grade of recommendation***

References used in the text have been assessed according to their level of scientific evidence (Table 1), and guideline recommendations have been graded (Table 2) according to the Oxford Centre for Evidence-based Medicine Levels of Evidence (4). The aim of grading recommendations is to provide transparency between the underlying evidence and the recommendation given.

Table 1: Level of evidence (LE)*

Level	Type of evidence
1a	Evidence obtained from meta-analysis of randomised trials.
1b	Evidence obtained from at least one randomised trial.
2a	Evidence obtained from one well-designed controlled study without randomisation.
2b	Evidence obtained from at least one other type of well-designed quasi-experimental study.
3	Evidence obtained from well-designed non-experimental studies, such as comparative studies, correlation studies and case reports.
4	Evidence obtained from expert committee reports or opinions or clinical experience of respected authorities.

** Modified from Sackett, et al. (4).*

It should be noted that when recommendations are graded, the link between the level of evidence and grade of recommendation is not directly linear. Availability of RCTs may not necessarily translate into a grade A recommendation where there are methodological limitations or disparity in published results.

Alternatively, absence of high level evidence does not necessarily preclude a grade A recommendation, if there

is overwhelming clinical experience and consensus. In addition, there may be exceptional situations where corroborating studies cannot be performed, perhaps for ethical or other reasons and in this case unequivocal recommendations are considered helpful for the reader. The quality of the underlying scientific evidence - although a very important factor - has to be balanced against benefits and burdens, values and preferences and costs when a grade is assigned (5-7).

The EAU Guidelines Office do not perform cost assessments, nor can they address local/national preferences in a systematic fashion. But whenever this data is available, the expert panels will include the information.

Table 2: Grade of recommendation (GR)*

Grade	Nature of recommendations
A	Based on clinical studies of good quality and consistency addressing the specific recommendations and including at least one randomised trial.
B	Based on well-conducted clinical studies, but without randomised clinical trials.
C	Made despite the absence of directly applicable clinical studies of good quality.

**Modified from Sackett, et al. (4).*

*1.2.4 **Publication history***

The current guidelines present a limited update of the 2008 publication. The EAU published the first guidelines on Neurogenic LUTS 2003 with an update in 2008. A review paper was published in the scientific journal of the association in 2009 (8).

A quick reference document presenting the main findings of the Neurogenic LUTS guidelines is available. All texts can be viewed and downloaded for personal use at the EAU website: http://www.uroweb.org/guidelines/online-guidelines/.

There is a need for ongoing re-evaluation of the information presented in the current guidelines by an expert panel. It must be emphasised that clinical guidelines present the best evidence available to the experts but following guideline recommendations will not necessarily result in the best outcome. Guidelines can never replace clinical expertise when making treatment decisions for individual patients, but rather help to focus decisions - also taking personal values and preferences/individual circumstances of patients into account.

Summary of updated information

An updated literature search was done covering the chapters on Epidemiology, Diagnosis and Assessment, Medical Treatment, Sexuality/Fertility and Quality of Life. New additions are the Introduction in this chapter 1, Bladder Rehabilitation and the chapters on Infections, Sexual Dysfunction and Fertility. Chapter 2 “Epidemiology” has been updated and chapter 3 “Diagnosis” completely renewed.

Readers are advised to consult the other EAU guidelines which may address different aspects of the topics discussed in this document.

1.3 Introduction

The function of the lower urinary tract (LUT) is mainly storage and voiding of urine, which is regulated by a neural control system in the brain and spinal cord that coordinates the activity of the urinary bladder and bladder outlet. Therefore, any disturbance of the nervous systems that control the LUT, including the peripheral nerves in the pelvis, can result in neurogenic lower urinary tract dysfunction (NLUTD). Depending on the extent and location of the disturbance, a variety of different NLUTDs might occur, which can be symptomatic or asymptomatic. Moreover, NLUTD can cause a variety of long-term complications; the most dangerous being damage of renal function. As symptoms and long-term complications do not correlate (9), it is important to identify patients with NLUTD, and establish if they have a low or high risk of subsequent complications.

According to current knowledge, elevated storage pressure in the bladder, either alone or combined with vesicoureteric reflux (VUR), is the most important risk factor for renal damage (10). Sustained elevated storage pressure in the bladder is mainly due to a combination of increased detrusor activity during the storage phase (detrusor overactivity [DO] or low compliance), combined with detrusor-sphincter-dyssynergia (DSD). The combination of these two findings is mainly caused by suprasacral infrapontine spinal lesions. Furthermore, elevated detrusor leak point pressure has been demonstrated to be a risk factor for renal deterioration in patients with meningomyelocele (11). Therefore, renal failure has been the leading cause of death in patients with spinal cord injury for a long time (12). Even today, 26% of patients with

meningomyelocele who do not undergo urological treatment develop renal damage. Detrusor leak point pressure ≥ 40 cm H_2O and low bladder compliance are the main risk factors for renal damage (13).

In recent years, adequate diagnosis and treatment of NLUTD in patients with spinal cord lesions have improved the situation of these patients. Nowadays, respiratory diseases are the most frequent (21%) cause of death in patients with SCI (14).

In all other patients with NLUTD, the risk of renal damage is significantly lower. However, in Multiple Sclerosis (MS), urodynamics and clinical symptoms do not correlate, which means that asymptomatic patients can present with abnormal urodynamic findings (15). LUT symptoms do not always lead to urological evaluation in patients with MS, even if the symptoms are troublesome (16). Therefore, urological assessment is important in MS patients (17); although respiratory diseases are currently the leading cause of death for patients with MS (18).

In Parkinson disease (PD), NLUTD has not been mentioned as a significant cause of death. Moreover, patients with PD commonly suffer from overactive bladder without DSD (19), which does not seem to be as threatening to the upper urinary tract as DO with DSD. In patients with PD, urodynamic diagnosis of DO correlates well with diagnosis made by questionnaires (20). For these reasons, regular urodynamic follow-up might be less important in PD patients compared with patients suffering from MS or SCI. The same is true for type 2 diabetes, which frequently leads to NLUTD (21), but cardiovascular diseases are the main cause of death in these patients (22).

In summary, treatment and intensity of follow-up examinations are based on the type of NLUTD and the underlying cause.

1.4 References

1. Stöhrer M, Goepel M, Kondo A, et al. The standardization of terminology in neurogenic lower urinary tract dysfunction with suggestions for diagnostic procedures. International Continence Society Standardization Committee. Neurourol Urodyn 1999;18(2):139-58. http://www.ncbi.nlm.nih.gov/pubmed/10081953
2. 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(2):167-78. http://www.ncbi.nlm.nih.gov/pubmed/11857671
3. Schäfer W, Abrams P, Liao L, et al. International Continence Society. Good urodynamic practices: uroflowmetry, filling cystometry, and pressure-flow Studies. Neurourol Urodyn 2002;21(3):261-74. http://www.ncbi.nlm.nih.gov/pubmed/11948720
4. Oxford Centre for Evidence-based Medicine Levels of Evidence (May 2009). Produced by Bob Phillips, Chris Ball, Dave Sackett, Doug Badenoch, Sharon Straus, Brian Haynes, Martin Dawes since November 1998. Updated by Jeremy Howick March 2009. http://www.cebm.net/index.aspx?o=1025 [Access date Nov 2012]
5. Guyatt GH, Oxman AD, Kunz R, et al; GRADE Working Group. Going from evidence to recommendations. BMJ 2008 May 10;336(7652):1049-51. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2376019/?tool=pubmed
6. Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008;336(7650):924-6. http://www.ncbi.nlm.nih.gov/pubmed/18436948
7. Guyatt GH, Oxman AD, Kunz R, et al. GRADE Working Group. Going from evidence to recommendations. BMJ 2008 May 10;336(7652):1049-51. http://www.bmj.com/content/336/7652/1049.long
8. Stöhrer M, Blok B, Castro-Diaz D, et al. EAU guidelines on neurogenic lower urinary tract dysfunction. Eur Urol 2009 Jul;56(1):81-8. http://www.ncbi.nlm.nih.gov/pubmed/19403235
9. Nosseir M, Hinkel A, Pannek J. Clinical usefulness of urodynamic assessment for maintenance of bladder function in patients with spinal cord injury. Neurourol Urodyn 2007;26(2);228-33. http://www.ncbi.nlm.nih.gov/pubmed/16998859
10. Gerridzen RG, Thijssen AM, Dehoux E. Risk factors for upper tract deterioration in chronic spinal cord injury patients. J Urol 1992 Feb;147(2):416-8. http://www.ncbi.nlm.nih.gov/pubmed/1732606
11. McGuire EJ, Woodside JR, Borden TA, et al. Prognostic value of urodynamic testing in myelodysplastic patients. J Urol 1981 Aug;126(2); 205-9. http://www.ncbi.nlm.nih.gov/pubmed/7196460

12. Hackler RH. A 25-year prospective mortality study in the spinal cord injured patient: comparison with the long-term living paraplegic. J Urol 1977 Apr;117(4):486-8.
http://www.ncbi.nlm.nih.gov/pubmed/850323
13. Bruschini H, Almeida FG, Srougi M. Upper and lower urinary tract evaluation of 104 patients with myelomeningocele without adequate urological management. World J Urol 2006 Jun;24(2):224-8.
http://www.ncbi.nlm.nih.gov/pubmed/16758253
14. Lidall IB, Snekkevik H, Aamodt G, et al. Mortality after spinal cord injury in Norway. J Rehabil Med 2007 Mar;39(2):145-51.
http://www.ncbi.nlm.nih.gov/pubmed/17351697
15. Del Popolo G, Panariello G, Del Corso F, et al. Diagnosis and therapy for neurogenic bladder dysfunctions in multiple sclerosis patients. Neurol Sci 2008 Dec;29 Suppl 4:S352-5.
http://www.ncbi.nlm.nih.gov/pubmed/19089675
16. Marrie RA, Cutter G, Tyry T, et al. Disparities in the management of multiple sclerosis-related bladder symptoms. Neurology 2007 Jun 5;68(23):1971-8.
http://www.ncbi.nlm.nih.gov/pubmed/17548546
17. de Sèze M, Ruffion A, Denys P, et al. GENULF. The neurogenic bladder in multiple sclerosis: review of the literature and proposal of management guidelines. Mult Scler 2007 Aug;13(7):915-28.
http://www.ncbi.nlm.nih.gov/pubmed/17881401
18. Ragonese P, Aridon P, Salemi G, et al. Mortality in multiple sclerosis: A review. Eur J Neurol 2008 Feb;15(2):123-7.
http://www.ncbi.nlm.nih.gov/pubmed/18217882
19. Sakakibara R, Hattori T, Uchiyama T, et al. Videourodynamic and sphincter motor unit potential analyses in Parkinson's disease and multiple system atrophy. J Neurol Neurosurg Psychiatry 2001 Nov;71(5):600-6.
http://www.ncbi.nlm.nih.gov/pubmed/11606669
20. Palleschi G, Pastore AL, Stocchi F, et al. Correlation between the Overactive Bladder questionnaire (OAB-q) and urodynamic data of Parkinson disease patients affected by neurogenic detrusor overactivity during antimuscarinic treatment. Clin Neuropharmacol 2006 Jul-Aug;29(4):220-9.
http://www.ncbi.nlm.nih.gov/pubmed/16855424
21. Frimodt-Møller C. Diabetic cystopathy: epidemiology and related disorders. Ann Intern Med 1980 Feb;92(2 Pt 2):318-21.
http://www.ncbi.nlm.nih.gov/pubmed/7356221
22. Brown SH, Abdelhafiz AH. Trials review: cardiovascular outcome with intensive glycemic control and implications for patients with type 2 diabetes. Postgrad Med 2009 Sep;121(5):31-41.
http://www.ncbi.nlm.nih.gov/pubmed/19820272

2. RISK FACTORS AND EPIDEMIOLOGY

2.1 Introduction

Neurogenic lower urinary tract dysfunction may be caused by various diseases and events affecting the nervous systems controlling the LUT. The resulting LUTD depends grossly on the location and the extent of the neurological lesion (see also Section 2.3).

There are no figures on the overall prevalence of NLUTD in the general population, but data are available on the prevalence of the underlying conditions and the relative risk of those for the development of NLUTD. It is important to realise that most of these data show a very wide range of prevalence figures because of the low level of evidence in most published data and smaller sample sizes.

*2.1.1 **Brain tumours***

Brain tumours can cause LUTD in 24% of patients (1). More recently, mostly case reports to small series have been published (2-3). In a series of patients with brain tumours, voiding difficulty was reported in 46/152 (30%) of patients with tumours in the posterior fossa, while urinary incontinence occurred in only three (1.9%) patients (4). Urinary retention was found in 12/17 (71%) children with pontine glioma (5).

*2.1.2 **Dementia***

It is not easy to distinguish dementia-associated LUTD from LUTD caused by age-related changes of the bladder and other concomitant diseases. Therefore, the true incidence of incontinence caused by dementia is unknown. However, it has been shown that incontinence is much more frequent in geriatric patients with

dementia than in patients without dementia (6,7).

Alzheimer, Lewy body dementia, Binswanger, Nasu-Hakola and Pick diseases frequently cause NLUTD (8-13). The occurrence of incontinence is reported to be between 23% and 48% (14,15) in patients with Alzheimer's disease. In Lewy body dementia, 92% of NLUTD is attributed to DO and 53% to incontinence (16). The onset of incontinence usually correlates with disease progression (17). A male-to-female ratio of dementia-related incontinence was found to be 1:15.

*2.1.3 **Mental retardation***

In mental retardation, depending on the grade of the disorder, 12-65% of LUTD has been described (18,19).

*2.1.4 **Cerebral palsy***

Lower urinary tract dysfunction has been described in about 30-40% (20,21).

*2.1.5 **Normal pressure hydrocephalus***

There have only been case reports of LUTD (22-24).

*2.1.6 **Basal ganglia pathology (Parkinson disease, Huntington's disease, Shy-Drager syndrome, etc.)***

Parkinson disease is accompanied by NLUTD in 37.9-70% (25-27).

In the rare Shy-Drager syndrome, almost all patients have NLUTD (27), with incontinence found in 73% (28).

Hattori, et al. (29) reported that 60% of Parkinson patients had urinary symptoms. However, Gray et al. (30) reported that functional disturbances of the LUT in PD were not disease-specific and were correlated only with age. Control-based studies have given the prevalence of LUT symptoms as 27-63.9% using validated questionnaires (31-33), or 53% in men and 63.9% in women using a validated questionnaire, which included a urinary incontinence category (33), with all these values being significantly higher than in healthy controls. Ransmayr reported a prevalence of urge episodes and urge incontinence in 53% Lewy body patients, whereas this was observed in 27% of the PD study population, of which 46% were also diagnosed with DO (34). In most patients, the onset of the bladder dysfunction occurred after the motor disorder had appeared.

*2.1.7 **Cerebrovascular pathology***

Cerebrovascular (CVA) pathology causes hemiplegia with remnant incontinence NLUTD in 20-50% of patients (35,36), with decreasing prevalence in the post-insult period (37). In 1996, 53% of patients with CVA pathology had significant urinary complaints at 3 months (38). Without proper treatment, at 6 months after the CVA, 20-30% of patients still suffered from urinary incontinence (39). The commonest cystometric finding was DO (40-45).

In 39 patients who had brainstem strokes, urinary symptoms were present in almost 50%, nocturia and voiding difficulty in 28%, urinary retention in 21%, and urinary incontinence in 8%. Several case histories have been published presenting difficulties with micturition in the presence of various brainstem pathologies (46-48).

*2.1.8 **Demyelinisation***

Multiple sclerosis causes NLUTD in 50-90% of the patients (49-51). The reported incidence of voiding dysfunction in multiple sclerosis is 33-52% in patients sampled consecutively, regardless of urinary symptoms. This incidence is related to the disability status of the patient (52). There is almost a 100% chance of having LUTD once these patients experience difficulties with walking. NLUTD is the presenting symptom in 2-12% of patients, with this finding being as high as 34% in some studies (53). LUTD appears mostly during the 10 years following the diagnosis (54).

*2.1.9 **Spinal cord lesions***

Spinal cord lesions can be traumatic, vascular, medical or congenital. An incidence of 30-40 new cases per million population is the accepted average for the USA. Most of these patients will develop NLUTD (55). The prevalence of spina bifida and other congenital nerve tube defects in the UK is 8-9 per 10,000 aged 10-69 years, with the greatest prevalence in the age group 25-29 years (56), and in the USA 1 per 1,000 births (57). The incidence of urethrovesical dysfunction in myelomeningocele is not completely known, but most studies suggest it is very high at 90-97% (58). About 50% of these children will have DSD (59,60).

In a large review specific data were presented for intradural metastasis from renal carcinoma with 22% of patients presenting with NLUTD (61).

Central cord syndrome is an incomplete SCI. A case series (n = 50) presented NLUTD in 42% of patients at admission, 12% had residual disturbance during follow up, but most of the 12% related to patients > 70 years old (60% of that age bracket) (62).

In a hereditary spastic paraplegia series, 38 (77.6%) out of 49 patients presented with NLUTD (63).

Caudal Regression Syndrome (CRS): In a case series 61% of patients diagnosed with CRS presented with NLUTD (n = 69). 20% of these CRS patients presented with one kidney (64).
Special attention is to be paid to the combination of traumatic SCI and brain injuries: the incidence of traumatic SCI with clinical concomitant brain injury has increased over the past 50 years. These findings have consequences for the diagnosis and treatment of NLUTD (65).
In 25% of children with high anorectal malformations, innate NLUTD is present (66).

2.1.10 ***Disc disease***

This is reported to cause NLUTD in 28-87% of the patients (< 20%) (67,68). The incidence of cauda equine syndrome due to central lumbar disc prolapse is relatively rare and is about 1-5% of all prolapsed lumbar discs (68-75). There have been case reports of NLUTD without cauda equine syndrome (76) and small series with 90% cure of incontinence (77).

2.1.11 ***Spinal stenosis and spine surgery***

About 50% of patients seeking help for intractable leg pain due to spinal stenosis report symptoms of LUTD, such as a sense of incomplete bladder emptying, urinary hesitancy, incontinence, nocturia or urinary tract infections (UTIs) (78). These symptoms may be overlooked or attributed to primary urological disorders, with 61-62% affected by LUTD (79,80). The prevalence of neurological bladder is more significantly associated with the anteroposterior diameter of the dural sac than with its cross-sectional area. Spinal surgery is related to LUTD in 38-60% of patients (81,82). In a series with sacrectomy for sacral chordoma's NLUTD was found in 74% (83).

2.1.12 ***Peripheral neuropathy***

Diabetes: This common metabolic disorder has a prevalence of about 2.5% in the American population, but the disease may be subclinical for many years. No specific criteria exist for secondary neuropathy in this condition, but it is generally accepted that 50% of patients will develop somatic neuropathy, with 75-100% of these patients developing NLUTD (84,85). Diabetic patients suffer from various polyneuropathies, with 'diabetic cystopathy' reported in 43-87% of insulin-dependent diabetics without gender or age differences. It is also described in about 25% of type 2 diabetic patients on oral hypoglycaemic treatment (86).

The prevalence of NLUTD in type 2 diabetes gets higher with increasing severity of cardiac autonomic neuropathy (87).

Alcohol abuse will eventually cause peripheral neuropathy. This has a reported prevalence that varies widely from 5-15% (88) to 64% (89). NLUTD is probably more likely to be present in patients with liver cirrhosis. The parasympathetic nervous system is attacked more than the sympathetic nervous system (89).

Less prevalent peripheral neuropathies include the following:

- Porphyria: bladder dilatation occurs in up to 12% of patients (90).
- Sarcoidosis: NLUTD is rare (91).
- Lumbosacral zone and genital herpes: incidence of LUT dysfunction is as high as 28% when only lumbosacral dermatome-involved patients are considered. The overall incidence is 4% (92,93). NLUTD is transient in most patients.
- Guillain Barré syndrome: the prevalence of micturition disorders varies from 25% to more than 80% (94,95), but is regressive in most cases (96). The true incidence is uncertain because, during the acute phase, patients are usually managed by indwelling catheter.

2.1.13 ***Other conditions (systematic lupus erythaematosus)***

Nervous system involvement occurs in about half of patients with systemic lupus erythaematosus (SLE). Symptoms of LUTD can occur, but data on prevalence are rare and give an incidence of 1% (97,98).

In familial amyloidotic polyneuropathy (FAP) approx. 50% of patients present with NLUTD (99).

2.1.14 ***Human immunodeficiency virus***

Voiding problems have been described in 12% of HIV-infected patients, mostly in advanced stages of the disease (100,101).

2.1.15 ***Regional spinal anaesthesia***

This may cause NLUTD but no prevalence figures have been found (102,103).
NLUTD have been described after image-guided transforaminal lumbar spine epidural steroid injection (104), and intrathecal methotrexate injection (105).

2.1.16 ***Iatrogenic***

Abdominoperineal resection of the rectum has been described as causing NLUTD in up to 50% of patients (106,107). One study reported that NLUTD remains a long-term problem in only 10% (108); however, the study was not clear whether this was because the neurological lesion was cured or bladder rehabilitation was successful. Surgical prevention with nerve preservation was shown to be important (109,110).

NLUTD has been reported following simple hysterectomy (111) and in 8-57% of patients following radical hysterectomy or pelvic irradiation for cervical cancer (112-115). Surgical prevention can be used (116). Neurological dysfunction of the pelvic floor has been demonstrated following radical prostatectomy (117).

2.2 Standardisation of terminology

2.2.1 ***Introduction***

Several national or international guidelines have already been published for the care of patients with NLUTD (118-121). The ICS NLUTD standardisation report (119) deals specifically with the standardisation of terminology and urodynamic investigation in patients with NLUTD. Other relevant definitions are found in the general ICS standardisation report (122).

Section 2.2.2 lists the definitions from these references, partly adapted, and other definitions considered useful for clinical practice in NLUTD (Tables 3 and 4). For specific definitions relating to urodynamic investigation, the reader is referred to the appropriate ICS report (119).

2.2.2 ***Definitions***

Table 3: Definitions useful in clinical practice

Acontractility, detrusor	*See below under voiding phase (table 4)*
Acontractility, urethral sphincter	*See below under storage phase (table 4)*
Autonomic dysreflexia	Increase of sympathetic reflex due to noxious stimuli with symptoms or signs of headache, hypertension, flushing face and perspiration
Capacity	*See below under storage phase*
Catheterisation, indwelling	Emptying of the bladder by a catheter that is introduced (semi-)permanently
Catheterisation, intermittent (IC)	Emptying of the bladder by a catheter that is removed after the procedure, mostly at regular intervals
• Aseptic IC	The catheters remain sterile, the genitals are disinfected, and disinfecting lubricant is used
• Clean IC	Disposable or cleansed re-usable catheters, genitals washed
• Sterile IC	Complete sterile setting, including sterile gloves, forceps, gown and mask
• Intermittent self-catheterisation (ISC)	IC performed by the patient
Compliance, detrusor	*See below under storage phase*
Condition	Evidence of relevant pathological processes
Diary, urinary	Record of times of micturitions and voided volumes, incontinence episodes, pad usage, and other relevant information

• Frequency volume chart (FVC)	Times of micturitions and voided volumes only
• Micturition time chart (MTC)	Times of micturitions only
Filling rate, physiological	Below the predicted maximum: body weight (kg) / 4 in mL/s (122,123)
Hesitancy	Difficulty in initiating micturition; delay in the onset of micturition after the individual is ready to pass urine
Intermittency	Urine flow stops and starts on one or more occasions during voiding
Leak point pressure (LPP)	*See below under storage phase*
Lower motor neuron lesion (LMNL)	Lesion at or below the S1-S2 spinal cord level
Neurogenic lower urinary tract dysfunction (NLUTD)	Lower urinary tract dysfunction secondary to confirmed pathology of the nervous supply
Observation, specific	Observation made during specific diagnostic procedure
Overactivity, bladder	*See below under symptom syndrome (table 4)*
Overactivity, detrusor	*See below under storage phase*
Rehabilitation, LUT	Non-surgical non-pharmacological treatment for LUT dysfunction
Sign	To verify symptoms and classify them
Sphincter, urethral, non-relaxing	*See below under voiding phase*
Symptom	Subjective indicator of a disease or change in condition, as perceived by the patient, carer, or partner that may lead the patient to seek help from healthcare professionals
Upper motor neuron lesion (UMNL)	Lesion above the S1-S2 spinal cord level
Voiding, balanced: In patients with NLUTD (< 80 mL or < 20% of bladder volume)	Voiding with physiological detrusor pressure and low residual
Voiding, triggered	Voiding initiated by manoeuvres to elicit reflex detrusor contraction by exteroceptive stimuli
Volume, overactivity	*See below under storage phase*

Table 4: Further definitions useful in clinical practice

Storage phase	
Maximum anaesthetic bladder capacity	Maximum bladder filling volume under deep general or spinal anaesthesia
Increased daytime frequency	Self-explanatory; the normal frequency can be estimated at about 8 times per day (124)
Nocturia	Waking at night one or more times to void
Urgency	The symptom of a sudden compelling desire to pass urine that is difficult to defer
Urinary incontinence	Any involuntary leakage of urine
• Stress urinary incontinence	On effort or exertion, or on sneezing or coughing
• Urge urinary incontinence	Accompanied by or immediately preceded by urgency
• Mixed urinary incontinence	Associated with urgency but also exertion, effort, sneezing, or coughing
• Continuous urinary incontinence	
Bladder sensation	
Normal	
• Symptom and history	Awareness of bladder filling and increasing sensation up to a strong desire to void

• Urodynamics	First sensation of bladder filling, first desire to void, and strong desire to void at realistic bladder volumes
Increased	
• Symptom and history	An early and persistent desire to void
• Urodynamics	Any of the three urodynamic parameters mentioned under 'normal' persistently at low bladder volume
Reduced	
• Symptom and history	Awareness of bladder filling but no definite desire to void
• Urodynamics	Diminished sensation throughout bladder filling
Absent	No sensation of bladder filling or desire to void
Non-specific	Perception of bladder filling as abdominal fullness, vegetative symptoms, or spasticity
Definitions valid after urodynamic confirmation only	
Cystometric capacity	Bladder volume at the end of the filling cystometry
• Maximum cystometric capacity	Bladder volume at strong desire to void
• High-capacity bladder	Bladder volume at cystometric capacity far over the mean voided volume, estimated from the bladder diary, with no significant increase in detrusor pressure under non-anaesthetised condition
Normal detrusor function	Little or no pressure increase during filling: no involuntary phasic contractions despite provocation
Detrusor overactivity	Involuntary detrusor contractions during filling; spontaneous or provoked
• Phasic DO	Characteristic phasic contraction
• Terminal DO	A single contraction at cystometric capacity
• High pressure DO	Maximal detrusor pressure > 40 cm H_2O (119,125)
• Overactivity volume	Bladder volume at first occurrence of DO
• Detrusor overactivity incontinence	Self-explanatory
Leak point pressure	
• Detrusor leak point pressure (DLPP)	Lowest value of detrusor pressure at which leakage is observed in the absence of abdominal strain or detrusor contraction
• Abdominal leak point pressure	Lowest value of intentionally increased intravesical pressure that provokes leakage in the absence of a detrusor contraction
Detrusor compliance	Relationship between change in bladder volume (ΔV) and change in detrusor pressure ($\Delta pdet$):$C=\Delta V/\Delta pdet$ (mL/ cmH_2O)
• Low detrusor	compliance $C=\Delta V/\Delta pdet$ < 20 mL/cm H_2O (106)
Break volume	Bladder volume after which a sudden significant decrease in detrusor compliance is observed
Urethral sphincter acontractility	No evidence of sphincter contraction during filling, particularly at higher bladder volumes, or during abdominal pressure increase
Voiding phase	
• Slow stream	Reduced urine flow rate
• Intermittent stream (intermittency)	Stopping and starting of urine flow during micturition
• Hesitancy	Difficulty in initiating micturition
• Straining	Muscular effort to initiate, maintain, or improve urinary stream

• Terminal dribble	Prolonged final part of micturition when the flow has slowed to a trickle/dribble
Definitions valid after urodynamic confirmation only	
Normal detrusor function	Voluntarily initiated detrusor contraction that causes complete bladder emptying within a normal time span
Detrusor underactivity	Contraction of reduced strength/duration
Acontractile detrusor	Absent contraction
Non-relaxing urethral sphincter	Self-explanatory
Detrusor sphincter dyssynergia (DSD)	Detrusor contraction concurrent with an involuntary contraction of the urethra and/or periurethral striated musculature
Post-micturition phase Feeling of incomplete emptying (symptom only) Post-micturition dribble: involuntary leakage of urine shortly after finishing the micturition Pain, discomfort or pressure sensation in the LUT and genitalia that may be related to bladder filling or voiding, may be felt after micturition, or be continuous	
Symptom syndrome: combination of symptoms • Overactive bladder syndrome: urgency with or without urge incontinence, usually with frequency and nocturia • Synonyms: urge syndrome, urgency-frequency syndrome • This syndrome is suggestive for LUTD	

2.3 ***References***

1. Andrew J, Nathan PW. Lesions of the anterior frontal lobes and disturbances of micturition and defecation. Brain 1964 Jun;87:233-62. [no abstract available] http://www.ncbi.nlm.nih.gov/pubmed/14188274
2. Maurice-Williams RS. Micturition symptoms in frontal tumours. J Neurol Neurosurg Psychiatry 1974 Apr;37(4):431-6. [no abstract available] http://www.ncbi.nlm.nih.gov/pubmed/4365244
3. Lang EW, Chesnut RM, Hennerici M. Urinary retention and space-occupying lesions of the frontal cortex. Eur Neurol 1996;36(1):43-7. http://www.ncbi.nlm.nih.gov/pubmed/8719650
4. Ueki K. Disturbances of micturition observed in some patients with brain tumor. Neurol Med Chir 1960;2:25-33.
5. Renier WO, Gabreels FJ. Evaluation of diagnosis and non-surgical therapy in 24 children with a pontine tumour. Neuropediatrics 1980 Aug;11(3):262-73. http://www.ncbi.nlm.nih.gov/pubmed/6252517
6. Toba K, Ouchi Y, Orimo H, et al. Urinary incontinence in elderly inpatients in Japan: a comparison between general and geriatric hospitals. Aging (Milano) 1996 Feb;8(1):47-54. http://www.ncbi.nlm.nih.gov/pubmed/8695676
7. Campbell AJ, Reinken J, McCosh L. Incontinence in the elderly: prevalence and prognosis. Age Ageing 1985 Mar;14(2):65-70. http://www.ncbi.nlm.nih.gov/pubmed/4003185
8. Horimoto Y, Matsumoto M, Akatsu H, et al. Autonomic dysfunctions in dementia with Lewy bodies. J Neurol 2003 May;250(5):530-3. http://www.ncbi.nlm.nih.gov/pubmed/12736730
9. Sugiyama T, Hashimoto K, Kiwamoto H, et al. Urinary incontinence in senile dementia of the Alzheimer type (SDAT). Int J Urol 1994 Dec;1(4):337-40. http://www.ncbi.nlm.nih.gov/pubmed/7614397
10. McGrother C, Resnick M, Yalla SV, et al. Epidemiology and etiology of urinary incontinence in the elderly. World J Urol 1998;16(Suppl 1):S3-9. http://www.ncbi.nlm.nih.gov/pubmed/9775412

11. Madersbacher H, Awad S, Fall M, et al. Urge incontinence in the elderly-supraspinal reflex incontinence. World J Urol 1998;16 (Suppl 1):S35-S43.
http://www.ncbi.nlm.nih.gov/pubmed/9775414
12. Olsen CG, Clasen ME. Senile dementia of the Binswanger's type. Am Fam Physician 1998 Dec;58(9):2068-74.
http://www.ncbi.nlm.nih.gov/pubmed/9861880
13. Honig LS, Mayeux R. Natural history of Alzheimer's disease. Aging (Milano) 2001 Jun;13:171-82.
http://www.ncbi.nlm.nih.gov/pubmed/11442300
14. Burns A, Jacoby R, Levy R. Psychiatric phenomena in Alzheimer's disease. IV: Disorders of behaviour. Br J Psychiatry 1990 Jul;157:86-94.
http://www.ncbi.nlm.nih.gov/pubmed/2397368
15. Cacabelos R, Rodríguez B, Carrera C, et al. APOE-related frequency of cognitive and noncognitive symptoms in dementia. Methods Find Exp Clin Pharmacol 1996 Dec;18(10):693-706.
http://www.ncbi.nlm.nih.gov/pubmed/9121226
16. Ransmayr GN, Holliger S, Schletterer K, et al. Lower urinary tract symptoms in dementia with Lewy bodies, Parkinson disease, and Alzheimer disease. Neurology 2008 Jan;70(4):299-303.
http://www.ncbi.nlm.nih.gov/pubmed/18209204
17. Leung KS, Ng MF, Pang FC, et al. Urinary incontinence: an ignored problem in elderly patients. Hong Kong Med J 1997 Mar;3(1):27-33.
http://www.ncbi.nlm.nih.gov/pubmed/11847353
18. Mitchell SJ, Woodthorpe J. Young mentally handicapped adults in three London boroughs: prevalence and degree of disability. J Epidemiol Community Health 1981 Mar;35(1):59-64.
http://www.ncbi.nlm.nih.gov/pubmed/7264535
19. Reid AH, Ballinger BR, Heather BB. Behavioural syndromes identified by cluster analysis in a sample of 100 severely and profoundly retarded adults. Psychol Med 1978 Aug;8(3):399-412.
http://www.ncbi.nlm.nih.gov/pubmed/704707
20. McNeal DM, Hawtrey CE, Wolraich ML, et al. Symptomatic neurologic bladder in a cerebral-palsied population. Dev Med Child Neurol 1983 Oct;25(5):612-6.
http://www.ncbi.nlm.nih.gov/pubmed/6354799
21. Decter RM, Bauer SB, Khoshbin S, et al. Urodynamic assessment of children with cerebral palsy. J Urol 1987 Oct;138(4 Pt 2):1110-2.
http://www.ncbi.nlm.nih.gov/pubmed/3656569
22. Jonas S, Brown J. Neurologic bladder in normal pressure hydrocephalus. Urology 1975 Jan;5(1): 44-50.
http://www.ncbi.nlm.nih.gov/pubmed/1114545
23. Black PM. Idiopathic normal-pressure hydrocephalus. Results of shunting in 62 patients. J Neurosurg 1980 Mar;52(3):371-7.
http://www.ncbi.nlm.nih.gov/pubmed/7359191
24. Mulrow CD, Feussner JR, Williams BC, et al. The value of clinical findings in the detection of normal pressure hydrocephalus. J Gerontol 1987 May;42(3):277-9.
http://www.ncbi.nlm.nih.gov/pubmed/3571862
25. Murnaghan GF. Neurogenic disorders of the bladder in Parkinsonism. Br J Urol 1961 Dec;33:403-9. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/14477379
26. Campos-Sousa RN, Quagliato E, da Silva BB, et al. Urinary symptoms in Parkinson's disease: prevalence and associated factors. Arq Neuropsiquiatr 2003 Jun;61(2B):359-63.
http://www.ncbi.nlm.nih.gov/pubmed/12894267
27. Salinas JM, Berger Y, De La Rocha RE, et al. Urological evaluation in the Shy Drager syndrome. J Urol 1986 Apr;135(4):741-3.
http://www.ncbi.nlm.nih.gov/pubmed/3959195
28. Chandiramani VA, Palace J, Fowler CJ. How to recognize patients with parkinsonism who should not have urological surgery. Br J Urol 1997 Jul;80(1):100-4.
http://www.ncbi.nlm.nih.gov/pubmed/9240187
29. Hattori T, Yasuda K, Kita K, et al. Voiding dysfunction in Parkinson's disease. Jpn J Psychiatry Neurol 1992 Mar;46(1):181-6.
http://www.ncbi.nlm.nih.gov/pubmed/1635308
30. Gray R, Stern G, Malone-Lee J. Lower urinary tract dysfunction in Parkinson's disease: changes relate to age and not disease. Age Ageing 1995 Nov;24(6):499-504.
http://www.ncbi.nlm.nih.gov/pubmed/8588540

31. Araki I, Kuno S. Assessment of voiding dysfunction in Parkinson's disease by the international prostate symptom score. J Neurol Neurosurg Psychiatry 2000 Apr;68(4):429-33. http://www.ncbi.nlm.nih.gov/pubmed/10727477
32. Lemack GE, Dewey RB, Roehrborn CG, et al. Questionnaire-based assessment of bladder dysfunction in patients with mild to moderate Parkinson's disease. Urology 2000 Aug;56(2):250-4. http://www.ncbi.nlm.nih.gov/pubmed/10925088
33. Sakakibara R, Uchiyama T, Yamanishi T, et al. Bladder and bowel dysfunction in Parkinson's disease. J Neural Transm 2008;115(3):443-60. http://www.ncbi.nlm.nih.gov/pubmed/18327532
34. Ransmayr GN, Holliger S, Schletterer K, et al. Lower urinary tract symptoms in dementia with Lewy bodies, Parkinson disease, and Alzheimer disease. Neurology 2008 Jan;70(4):299-303. http://www.ncbi.nlm.nih.gov/pubmed/18209204
35. Currie CT. Urinary incontinence after stroke. Br Med J (Clin Res Ed) 1986 Nov;293(6558):1322-3. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1342046/
36. Codine PH, Pellissier J, Manderscheidt JC, et al. Les troubles urinaires au cours des hémiplegies vasculaires. In: *Hémiplegie vasculaire et médicine de rééducation*. Pellisier J, ed. Paris, Masson, 1988, pp. 261-9.
37. Barer DH. Continence after stroke: useful predictor or goal of therapy? Age Ageing 1989 May;18(3):183-91. http://www.ncbi.nlm.nih.gov/pubmed/2782216
38. Sakakibara R, Hattori T, Yasuda K, et al. Micturitional disturbance after acute hemispheric stroke: analysis of the lesion site by CT and MRI. J Neurol Sci 1996 Apr;137(1):47-56. http://www.ncbi.nlm.nih.gov/pubmed/9120487
39. Nakayama H, Jørgensen HS, Pedersen PM, et al. Prevalence and risk factors of incontinence after stroke. The Copenhagen Stroke Study. 1997 Jan;28(1):58-62. http://www.ncbi.nlm.nih.gov/pubmed/8996489
40. Khan Z, Hertanu J, Yang WC, et al. Predictive correlation of urodynamic dysfunction and brain injury after cerebrovascular accident. J Urol 1981 Jul;126(1):86-8. [no abstract available] http://www.ncbi.nlm.nih.gov/pubmed/7253085
41. Tsuchida S, Noto H, Yamaguchi O, et al. Urodynamic studies on hemiplegic patients after cerebrovascular accident. Urology 1983 Mar;21(3):315-8. http://www.ncbi.nlm.nih.gov/pubmed/6836813
42. Kuroiwa Y, Tohgi H, Ono S, et al. Frequency and urgency of micturition in hemiplegic patients; relationship to hemisphere laterality of lesions. J Neurol 1987 Feb;234(2):100-2. http://www.ncbi.nlm.nih.gov/pubmed/3559632
43. Khan Z, Starer P, Yang WC, et al. Analysis of voiding disorders in patients with cerebrovascular accidents. Urology 1990 Mar;35(3):265-70. http://www.ncbi.nlm.nih.gov/pubmed/2316094
44. Taub NA, Wolfe CD, Richardson E, et al. Predicting the disability of first-time stroke sufferers at 1 year. 12-month follow-up of a population-based cohort in southeast England. Stroke 1994 Feb;25(2):352-7. http://www.ncbi.nlm.nih.gov/pubmed/8303744
45. Borrie MJ, Campbell AJ, Caradoc-Davies TH, et al. Urinary incontinence after stroke: a prospective study. Age Ageing 1986 May;15(3):177-81. http://www.ncbi.nlm.nih.gov/pubmed/3739856
46. Sakakibara R, Hattori T, Yasuda K, et al. Micturitional disturbance and the pontine tegmental lesion: urodynamic and MRI analyses of vascular cases. J Neurol Sci 1996 Sep;141(1-2):105-10. http://www.ncbi.nlm.nih.gov/pubmed/8880701
47. Betts CD, Kapoor R, Fowler CJ. Pontine pathology and voiding dysfunction. Br J Urol 1992 Jul;70(1):100-2. [no abstract available] http://www.ncbi.nlm.nih.gov/pubmed/1638364
48. Manente G, Melchionda D, Uncini A. Urinary retention in bilateral pontine tumour: evidence for a pontine micturition centre in humans. J Neurol Neurosurg Psychiatry 1996 Nov;61(5):528-9. http://www.ncbi.nlm.nih.gov/pubmed/8937354
49. Litwiller SE, Frohman EM, Zimmern PE. Multiple sclerosis and the urologist. J Urol 1999 Mar;161(3): 743-57. http://www.ncbi.nlm.nih.gov/pubmed/10022678
50. Giannantoni A, Scivoletto G, Di Stasi SM, et al. Lower urinary tract dysfunction and disability status in patients with multiple sclerosis. Arch Phys Med Rehabil 1999 Apr;80(4):437-41. http://www.ncbi.nlm.nih.gov/pubmed/10206607

51. Hinson JL, Boone TB. Urodynamics and multiple sclerosis. Urol Clin North Am 1996 Aug;23(3):475-81. http://www.ncbi.nlm.nih.gov/pubmed/8701560
52. Bemelmans BL, Hommes OR, Van Kerrebroeck PE, et al. Evidence for early lower urinary tract dysfunction in clinically silent multiple sclerosis. J Urol 1991 Jun;145(6):1219-24. http://www.ncbi.nlm.nih.gov/pubmed/2033697
53. DasGupta R, Fowler CJ. Sexual and urological dysfunction in multiple sclerosis: better understanding and improved therapies. Curr Opin Neurol 2002 Jun;15(3):271-8. http://www.ncbi.nlm.nih.gov/pubmed/12045724
54. Perrigot M, Richard F, Veaux-Renault V, et al. [Bladder sphincter disorders in multiple sclerosis: symptomatology and evolution. 100 cases.] Sem Hop 1982 Nov;58(43):2543-6. [Article in French] http://www.ncbi.nlm.nih.gov/pubmed/6297048
55. Burns AS, Rivas DA, Ditunno JF. The management of neurogenic bladder and sexual dysfunction after spinal cord injury. Spine (Phila Pa 1976) 2001 Dec 15;26(24 Suppl):S129-36. http://www.ncbi.nlm.nih.gov/pubmed/11805620
56. Lawrenson R, Wyndaele JJ, Vlachonikolis I, et al. A UK general practice database study of prevalence and mortality of people with neural tube defects. Clin Rehabil 2000 Dec;14(6):627-30. http://www.ncbi.nlm.nih.gov/pubmed/11128738
57. Selzman AA, Elder JS, Mapstone TB. Urologic consequences of myelodysplasia and other congenital abnormalities of the spinal cord. Urol Clin North Am 1993 Aug;20(3):485-504. http://www.ncbi.nlm.nih.gov/pubmed/8351774
58. Smith E. *Spina bifida and the total care of spinal myelomeningocoele*. Springfield, IL: CC Thomas, ed, 1965; pp. 92-123.
59. van Gool JD, Dik P, de Jong TP. Bladder-sphincter dysfunction in myelomeningocele. Eur J Pediatr 2001 Jul;160(7):414-20. http://www.ncbi.nlm.nih.gov/pubmed/11475578
60. Wyndaele JJ, De Sy WA. Correlation between the findings of a clinical neurological examination and the urodynamic dysfunction in children with myelodysplasia. J Urol 1985 Apr;133(4):638-40. http://www.ncbi.nlm.nih.gov/pubmed/3981715
61. Jost G, Zimmerer S, Frank S, et al. Intradural spinal metastasis of renal cell cancer. Report of a case and review of 26 published cases. Acta Neurochir (Wien) 2009 Jul;151(7):815-21. http://www.ncbi.nlm.nih.gov/pubmed/19415167
62. Lenehan B, Street J, O'Toole P, et al. Central cord syndrome in Ireland: the effect of age on clinical outcome. Eur Spine J 2009 Oct;18(10):1458-63. http://www.ncbi.nlm.nih.gov/pubmed/19685249
63. Braschinsky M, Zopp I, Kals M, et al. Bladder dysfunction in hereditary spastic paraplegia: what to expect? J Neurol Neurosurg Psychiatry 2010 Mar;81(3):263-6. http://www.ncbi.nlm.nih.gov/pubmed/19726407
64. Torre M, Buffa P, Jasonni V, et al. Long-term urologic outcome in patients with caudal regression syndrome, compared with meningomyelocele and spinal cord lipoma. J Pediatr Surg 2008 Mar;43(3):530-3. http://www.ncbi.nlm.nih.gov/pubmed/18358295
65. Hagen EM, Eide GE, Rekand T, et al. Traumatic spinal cord injury and concomitant brain injury: a cohort study. Acta Neurol Scand Suppl 2010;(190):51-7. http://www.ncbi.nlm.nih.gov/pubmed/20586736
66. Borg H, Holmdahl G, Olsson I, et al. Impact of spinal cord malformation on bladder function in children with anorectal malformations. J Pediatr Surg 2009 Sep;44(9):1778-85. http://www.ncbi.nlm.nih.gov/pubmed/19735825
67. Bartolin Z, Gilja I, Bedalov G, et al. Bladder function in patients with lumbar intervertebral disc protrusion. J Urol 1998 Mar;159(3):969-71. http://www.ncbi.nlm.nih.gov/pubmed/9474195
68. O'Flynn KJ, Murphy R, Thomas DG. Neurologic bladder dysfunction in lumbar intervertebral disc prolapse. Br J Urol 1992 Jan;69(1):38-40. http://www.ncbi.nlm.nih.gov/pubmed/1737251
69. Jennett WB. A study of 25 cases of compression of the cauda equina by prolapsed intervertebral discs. J Neurol Neurosurg Psychiatry 1956 May;19(2):109-16. [no abstract available] http://www.ncbi.nlm.nih.gov/pubmed/13346384
70. Tay EC, Chacha PB. Midline prolapse of a lumbar intervertebral disc with compression of the cauda equina. J Bone Joint Surg Br 1979 Feb;61(1):43-6. http://www.ncbi.nlm.nih.gov/pubmed/154521

71. Nielsen B, de Nully M, Schmidt K, et al. A urodynamic study of cauda equina syndrome due to lumbar disc herniation. Urol Int 1980;35(3):167-70.
http://www.ncbi.nlm.nih.gov/pubmed/7385464
72. Bartels RH, de Vries J. Hemi-cauda equina syndrome from herniated lumbar disc: a neurosurgical emergency? Can J Neurol Sci 1996 Nov;23(4):296-9.
http://www.ncbi.nlm.nih.gov/pubmed/8951209
73. Goldman HB, Appell RA. Voiding dysfunction in women with lumbar disc prolapse. Int Urogynecol J Pelvic Floor Dysfunct 1999;10(2):134-8.
http://www.ncbi.nlm.nih.gov/pubmed/10384977
74. Ahn UM, Ahn NU, Buchowski JM, et al. Cauda equina syndrome secondary to lumbar disc herniation: a meta-analysis of surgical outcomes. Spine 2000 Jun;25(12):1515-22.
http://www.ncbi.nlm.nih.gov/pubmed/10851100
75. Shapiro S. Medical realities of cauda equina syndrome secondary to lumbar disc herniation. Spine 2000 Feb;25(3):348-51; discussion 352.
http://www.ncbi.nlm.nih.gov/pubmed/10703108
76. Emmett JL, Love JG. Urinary retention in women caused by asymptomatic protruded lumbar disc: report of 5 cases. J Urol 1968 May;99:597-606. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/5648558
77. Olivero WC, Wang H, Hanigan WC, et al. Cauda equina syndrome (CES) from lumbar disc herniations. J Spinal Disord Tech 2009 May;22(3):202-6.
http://www.ncbi.nlm.nih.gov/pubmed/19412023
78. Kawaguchi Y, Kanamori M, Ishihara H, et al. Clinical symptoms and surgical outcome in lumbar spinal stenosis patients with neurologic bladder. J Spinal Disord 2001 Oct;14(5):404-10.
http://www.ncbi.nlm.nih.gov/pubmed/11586140
79. Tammela TL, Heiskari MJ, Lukkarinen OA. Voiding dysfunction and urodynamic findings in patients with cervical spondylotic spinal stenosis compared with severity of the disease. Br J Urol 1992 Aug;70(2):144-8.
http://www.ncbi.nlm.nih.gov/pubmed/1393436
80. Inui Y, Doita M, Ouchi K, et al. Clinical and radiological features of lumbar spinal stenosis and disc herniation with neurologic bladder. Spine (Phila Pa 1976) 2004 Apr;29(8):869-73.
http://www.ncbi.nlm.nih.gov/pubmed/15082986
81. Boulis NM, Mian FS, Rodriguez D, et al. Urinary retention following routine neurosurgical spine procedures. Surg Neurol 2001 Jan;55(1):23-7; discussion 27-8.
http://www.ncbi.nlm.nih.gov/pubmed/11248301
82. Brooks ME, Moreno M, Sidi A, et al. Urologic complications after surgery on lumbosacral spine. Urology 1985 Aug;26:202-4.
http://www.ncbi.nlm.nih.gov/pubmed/4024418
83. Schwab JH, Healey JH, Rose P, et al. The surgical management of sacral chordomas. Spine (Phila Pa 1976) 2009 Nov 15;34(24):2700-4.
http://www.ncbi.nlm.nih.gov/pubmed/19910774
84. Ellenberg M. Development of urinary bladder dysfunction in diabetes mellitus. Ann Intern Med 1980 Feb;92(2 Pt 2):321-3.
http://www.ncbi.nlm.nih.gov/pubmed/7356222
85. Frimodt-Møller C. Diabetic cystopathy: epidemiology and related disorders. Ann Intern Med 1980 Feb;92:318-21.
http://www.ncbi.nlm.nih.gov/pubmed/7356221
86. Bradley WE. Diagnosis of urinary bladder dysfunction in diabetes mellitus. Ann Intern Med 1980 Feb;92(2 Pt 2):323-6.
http://www.ncbi.nlm.nih.gov/pubmed/7188844
87. Bilal N, Erdogan M, Ozbek M, et al. Increasing severity of cardiac autonomic neuropathy is associated with increasing prevalence of nephropathy, retinopathy, and peripheral neuropathy in Turkish type 2 diabetics. J Diabetes Complications 2008 May-Jun;22(3):181-5.
http://www.ncbi.nlm.nih.gov/pubmed/18413163
88. Barter F, Tanner AR. Autonomic neuropathy in an alcoholic population. Postgrad Med J 1987 Dec;63(746):1033-6.
http://www.ncbi.nlm.nih.gov/pubmed/3451229
89. Anonymous. Autonomic neuropathy in liver disease. Lancet 1989 Sep;2(8665):721-2. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/2570966

90. Bloomer JR, Bonkovsky HL. The porphyrias. Dis Mon 1989 Jan;35(1):1-54.
http://www.ncbi.nlm.nih.gov/pubmed/2645098
91. Chapelon C, Ziza JM, Piette JC, et al. Neurosarcoidosis: signs, course and treatment in 35 confirmed cases. Medicine (Baltimore) 1990 Sep;69(5):261-76.
http://www.ncbi.nlm.nih.gov/pubmed/2205782
92. Chen PH, Hsueh HF, Hong CZ. Herpes zoster-associated voiding dysfunction: a retrospective study and literature review. Arch Phys Med Rehabil 2002 Nov;83(11):1624-8.
http://www.ncbi.nlm.nih.gov/pubmed/12422336
93. Greenstein A, Matzkin H, Kaver I, et al. Acute urinary retention in herpes genitalis infection. Urodynamic evaluation. Urology 1988;31(5):453-6.
http://www.ncbi.nlm.nih.gov/pubmed/3363783
94. Grbavac Z, Gilja I, Gubarev N, et al. [Neurologic and urodynamic characteristics of patients with Guillain-Barré syndrome]. Lijec Vjesn 1989 Feb;111(1-2):17-20. [Article in Croatian]
http://www.ncbi.nlm.nih.gov/pubmed/2739495
95. Sakakibara R, Hattori T, Kuwabara S, et al. Micturitional disturbance in patients with Guillain-Barré syndrome. J Neurol Neurosurg Psychiatry 1997 Nov;63(5):649-53.
http://www.ncbi.nlm.nih.gov/pubmed/9408108
96. Lichtenfeld P. Autonomic dysfunction in the Guillain-Barré syndrome. Am J Med 1971 Jun;50(6): 772-80. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/5089852
97. Sakakibara R, Uchiyama T, Yoshiyama M, et al. Urinary dysfunction in patients with systemic lupus erythematosis. Neurourol Urodyn 2003;22(6):593-6.
http://www.ncbi.nlm.nih.gov/pubmed/12951670
98. Min JK, Byun JY, Lee SH, et al. Urinary bladder involvement in patients with systemic lupus erythematosus: with review of the literature. Korean J Intern Med 2000 Jan;15(1):42-50.
http://www.ncbi.nlm.nih.gov/pubmed/10714091
99. Andrade MJ. Lower urinary tract dysfunction in familial amyloidotic polyneuropathy, Portuguese type. Neurourol Urodyn 2009;28(1):26-32.
http://www.ncbi.nlm.nih.gov/pubmed/19089892
100. Gyrtrup HJ, Kristiansen VB, Zachariae CO, et al. Voiding problems in patients with HIV infection and AIDS. Scand J Urol Nephrol 1995 Sep;29(3):295-8.
http://www.ncbi.nlm.nih.gov/pubmed/8578272
101. Khan Z, Singh VK, Yang WC. Neurologic bladder in acquired immune deficiency syndrome (AIDS). Urology 1992 Sep;40(3):289-91.
http://www.ncbi.nlm.nih.gov/pubmed/1523760
102. Mardirosoff C, Dumont L. Bowel and bladder dysfunction after spinal bupivacaine. Anesthesiology 2001 Nov; 95(5):1306.
http://www.ncbi.nlm.nih.gov/pubmed/11685017
103. Auroy Y, Benhamou D, Bargues L, et al. Major complications of regional anesthesia in France: The SOS Regional Anesthesia Hotline Service. Anesthesiology 2002 Nov;97(5):1274-80.
http://www.ncbi.nlm.nih.gov/pubmed/12411815
104. Kennedy DJ, Dreyfuss P, Aprill CN, et al. Paraplegia following image-guided transforaminal lumbar spine epidural steroid injection: two case reports. Pain Med 2009 Nov;10(8):1389-94.
http://www.ncbi.nlm.nih.gov/pubmed/19863744
105. Pascual AM, Coret F, Casanova B, et al. Anterior lumbosacral polyradiculopathy after intrathecal administration of methotrexate. J Neurol Sci 2008 Apr 15;267(1-2):158-61.
http://www.ncbi.nlm.nih.gov/pubmed/17949753
106. Hollabaugh RS Jr, Steiner MS, Sellers KD, et al. Neuroanatomy of the pelvis: implications for colonic and rectal resection. Dis Colon Rectum 2000 Oct;43(10):1390-7.
http://www.ncbi.nlm.nih.gov/pubmed/11052516
107. Baumgarner GT, Miller HC. Genitourinary complications of abdominoperineal resection. South Med J 1976 Jul;69(7):875-7.
http://www.ncbi.nlm.nih.gov/pubmed/941055
108. Eickenberg HU, Amin M, Klompus W, et al. Urologic complications following abdominoperineal resection. J Urol 1976 Feb;1152(2):180-2.
http://www.ncbi.nlm.nih.gov/pubmed/1249871
109. Pocard M, Zinzindohoue F, Haab F, et al. A prospective study of sexual and urinary function before and after total mesorectal excision with autonomic nerve preservation for rectal cancer. Surgery 2002 Apr;131(4):368-72.
http://www.ncbi.nlm.nih.gov/pubmed/11935125

110. Kim NK, Aahn TW, Park JK, et al. Assessment of sexual and voiding function after total mesorectal excision with pelvic autonomic nerve preservation in males with rectal cancer. Dis Colon Rectum 2002 Sep;45(9):1178-85.
http://www.ncbi.nlm.nih.gov/pubmed/12352233
111. Parys BT, Woolfenden KA, Parsons KF. Bladder dysfunction after simple hysterectomy: urodynamic and neurological evaluation. Eur Urol 1990;17(2):129-33.
http://www.ncbi.nlm.nih.gov/pubmed/2311638
112. Sekido N, Kawai K, Akaza H. Lower urinary tract dysfunction as persistent complication of radical hysterectomy. Int J Urol 1997 May;4(3):259-64.
http://www.ncbi.nlm.nih.gov/pubmed/9255663
113. Zanolla R, Monzeglio C, Campo B, et al. Bladder and urethral dysfunction after radical abdominal hysterectomy: rehabilitative treatment. J Surg Oncol 1985 Mar;28(3):190-4.
http://www.ncbi.nlm.nih.gov/pubmed/3974245
114. Seski JC, Diokno AC. Bladder dysfunction after radical abdominal hysterectomy. Am J Obstet Gynecol 1977 Jul;128(6):643-51.
http://www.ncbi.nlm.nih.gov/pubmed/18009
115. Lin HH, Sheu BC, Lo MC, et al. Abnormal urodynamic findings after radical hysterectomy or pelvic irradiation for cervical cancer. Int J Gynaecol Obstet 1998 Nov;63(2):169-74.
http://www.ncbi.nlm.nih.gov/pubmed/9856324
116. Kuwabara Y, Suzuki M, Hashimoto M, et al. New method to prevent bladder dysfunction after radical hysterectomy for uterine cervical cancer. J Obstet Gynaecol Res 2000 Feb;26(1):1-8.
http://www.ncbi.nlm.nih.gov/pubmed/10761323
117. Zermann DH, Ishigooka M, Wunderlich H, et al. A study of pelvic floor function pre- and postradical prostatectomy using clinical neurourological investigations, urodynamics and electromyography. Eur Urol 2000 Jan;37(1):72-8.
http://www.ncbi.nlm.nih.gov/pubmed/10671789
118. Burgdörfer H, Heidler H, Madersbacher H, et al. [Guidelines for the urological management of paraplegic patients]. Urologe A 1998;37:222-8. [Article in German]
119. Stöhrer M, Goepel M, Kondo A, et al. The standardization of terminology in neurogenic lower urinary tract dysfunction with suggestions for diagnostic procedures, Neurourol Urodyn 1999;18(2):139-58.
http://onlinelibrary.wiley.com/doi/10.1002/(SICI)1520-6777(1999)18:2%3C139::AID-NAU9%3E3.0.CO;2-U/abstract;jsessionid=3A1E61B20A43C55D0A993A20A74C672F.d03t01
120. Wyndaele JJ, Castro D, Madersbacher H, et al. Neurologic urinary and faecal incontinence.
In: Abrams P, Cardozo L, Khoury S, Wein A, eds. *Incontinence*. Plymouth: Health Publications, 2005: 1061-2.
http://www.icsoffice.org/publications/ICI_3/v2.pdf/chap17.pdf
121. Consortium for Spinal Cord Medicine. Bladder management for adults with spinal cord injury: a clinical practice guideline for health-care providers. J Spinal Cord Med 2006;29(5):527-73.
http://www.ncbi.nlm.nih.gov/pubmed/17274492
122. 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(2):167-78.
http://www.ncbi.nlm.nih.gov/pubmed/11857671
123. Klevmark B. Natural pressure-volume curves and conventional cystometry. Scand J Urol Nephrol Suppl 1999;201:1-4.
http://www.ncbi.nlm.nih.gov/pubmed/10573769
124. Homma Y, Ando T, Yoshida M, et al. Voiding and incontinence frequencies: variability of diary data and required diary length. Neurourol Urodyn 2002;21(3):204-9.
http://www.ncbi.nlm.nih.gov/pubmed/11948713
125. McGuire EJ, Cespedes RD, O'Connell HE. Leak-point pressures. Urol Clin North Am 1996 May;23(2): 253-62.
http://www.ncbi.nlm.nih.gov/pubmed/8659025

3. DIAGNOSIS

3.1 Introduction

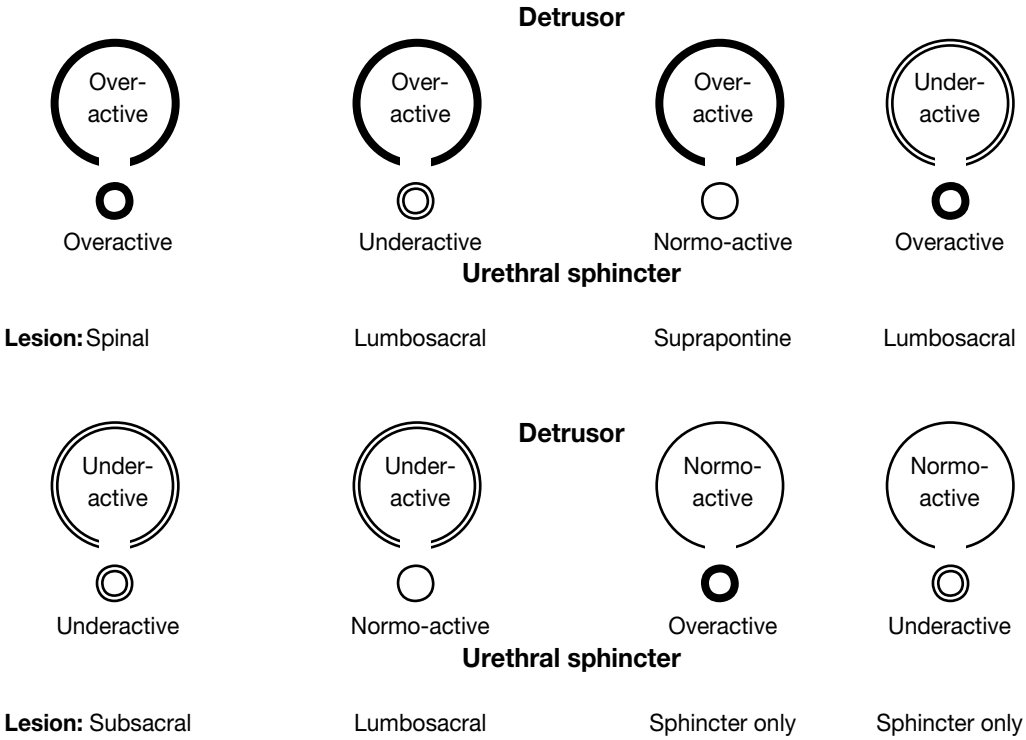
A thorough medical history and physical examination is mandatory, before any additional diagnostic

investigations are planned. The clinical assessment of patients with NLUTD includes a detailed history, a patient voiding diary and systematic physical examination. The initial evaluation is essential to determine the therapeutic scheme for long-term treatment and follow-up.

3.2 Classification

The NLUTD classification provides a standardised terminology. Several classification systems have been proposed, but a simple classification focusing on therapeutic consequences has been developed by Madersbacher (1) (LE: 4). This classification describes several NLUTD symptoms on the basis of the contraction state of the bladder and external urethral sphincter during voiding and filling phase (Figure 1).

Figure 1: Madersbacher classification system with typical neurogenic lesions [1]



3.3 Timing of diagnosis and treatment

Early diagnosis and treatment are essential in both congenital and acquired NLUTD. Irreversible changes within the LUT may occur, even with normal neurological reflexes (2,3) (LE: 3). Additionally, NLUTD can be the presenting feature of neurological pathology (4,5) (LE: 3). Early intervention, e.g. intermittent catheterisation (IC), can prevent irreversible deterioration of the lower and upper urinary tract (6) (LE: 3).

3.4 Patient history

History taking is the cornerstone of evaluation and should include past and present symptoms and disorders. The patient's past history should be taken in detail, particularly in cases of non-traumatic neurological bladder dysfunction with a slow insidious onset. Occasionally, this is traceable to childhood or adolescence (7) (LE: 4). Urinary history consists of symptoms related to both storage and evacuation functions of the LUT.

Bowel history is important since patients with NLUTD may suffer from a related neurogenic condition of the lower gastrointestinal tract. This may reflect the neurological condition of the urinary bladder (7) (LE: 4). Sexual function may also be impaired because of the neurogenic condition.

Table 5 gives an overview of the items that should be assessed. These items are important to guide the decision process of diagnostic investigations and treatment options.

Special attention should be paid to possible warning signs and symptoms (e.g. pain, infection, haematuria and fever) that warrant further investigation. However, it is usually difficult for patients with SCI to report accurately symptoms related to urinary tract infections (8-10) (LE: 3).

Table 5: History examination in neurogenic lower urinary tract dysfunction*	
Past history	
	Childhood - adolescence - adult
	Hereditary or familial risk factors
	Menarche (age)*; may suggest metabolic disorder*
	Obstetric history
	History of diabetes; *in some cases correction will resolve the neurological problem*
	Diseases, *e.g. syphilis, Parkinsonism, multiple sclerosis, encephalitis*
	Accidents and operations, *especially those involving the spine and central nervous system*
Present history	
	Present medication
	Lifestyle (smoking, alcohol and drugs); *may influence bowel and urinary function*
	Quality of life
	Life expectancy
Specific urinary history	
	Onset urological history
	Relief after voiding; *to detect the extent of a neurological lesion in the absence of obstructive uropathy*
	Bladder sensation
	Initiation of micturition *(normal, precipitate, reflex, strain, Credé)*
	Interruption of micturition *(normal, paradoxical, passive)*
	Enuresis
	Mode and type of voiding (catheterisation)
	Urinary diary*; (semi)objective information about number of voids, day- and night-time voiding frequency, volumes voided, incontinence, urge episodes*
Bowel history	
	Frequency and faecal incontinence
	Desire to defecate
	Defecation pattern
	Rectal sensation
	Initiation of defecation *(digital rectal stimulation)*
Sexual history	
	Genital or sexual dysfunction symptoms
	Sensation in genital area
	Specific male: erection, (lack of) orgasm, ejaculation
	Specific female: dyspareunia, (lack of) orgasm
Neurological history	
	Acquired or congenital neurological condition
	Mental status and comprehension
	Neurological symptoms (somatic and sensory), with onset, evolution and any treatment
	Spasticity or autonomic dysreflexia (lesion above level Th 6) Mobility and hand function

** Extracted from Bors and Turner ([7] (LE: 4; GR: C) and Stöhrer, et al. [11] (LE: 4; GR: C).*

Voiding diaries offer information on the number of voids, volumes voided, incontinence, and urge episodes. A 24-hour voiding diary was shown to be reliable in women with urinary incontinence (12,13) (LE: 3). However, no such information is available in patients with neurological incontinence. A voiding diary is also useful in patients performing intermittent catheterisation (11) (LE: 4).

3.5 Physical examination

In addition to a detailed patient history and a general examination, attention should be paid to possible physical and mental handicaps with respect to the planned investigation.

Neurological status should be described as completely as possible (Table 5). Patients with very high neurological lesions may suffer from a significant drop in blood pressure when moved in a sitting or standing position. All sensations and reflexes in the urogenital area must be tested. Furthermore, detailed testing of the anal sphincter and pelvic floor functions must be performed (Figure 2). Availability of this clinical information is essential for the reliable interpretation of subsequent diagnostic investigations.

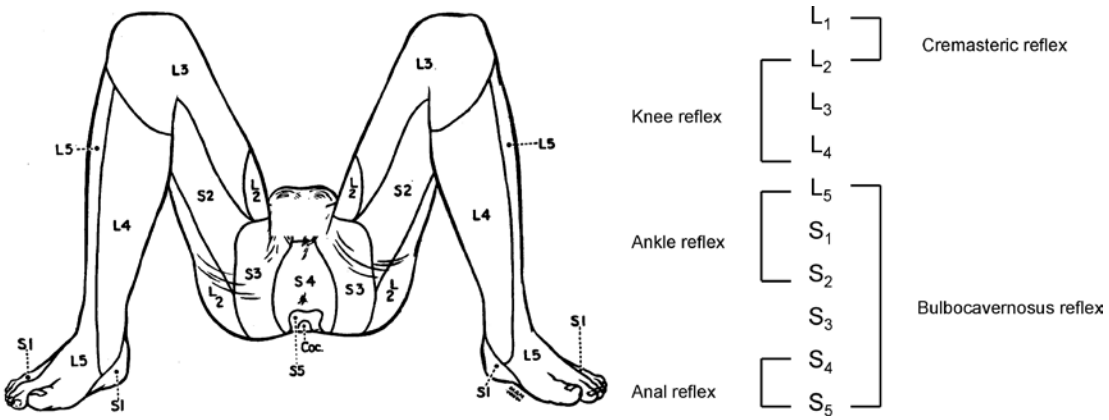


Figure 2: The neurological status of a patient with neurogenic lower urinary tract dysfunction (NLUTD) must be described as completely as possible: (a) dermatomes of spinal cord levels L2-S4; (b) urogenital and other reflexes in the lower spinal cord

Table 6: Neuro-urological items to be specified*

Sensations S2-S5 (both sides)	
	Presence (increased/normal/reduced/absent)
	Type (sharp/blunt)
	Afflicted segments
Reflexes (increased/normal/reduced/absent)	
	Bulbocavernous reflex
	Perianal reflex
	Knee and ankle reflexes
	Plantar responses (Babinski)
Anal sphincter tone	
	Presence (increased/normal/reduced/absent)
	Voluntary contractions of anal sphincter and pelvic muscles (increased/normal/reduced/absent)
Prostate palpation	
Descensus (prolapse) of pelvic organs	

**From Stöhrer, et al. [11] (LE: 4; GR: C).*

Caution

Autonomic dysreflexia (AD) is a sudden and exaggerated autonomic response to stimuli in patients with spinal cord injuries or dysfunction above level Th 5-Th 6. Hypertension is a relatively common manifestation of AD and can have life-threatening results if not properly managed (14-16) (LE: 3; GR: C).

3.5.1 *Recommendations for history taking and physical examination**

History taking	GR
An extensive general history is mandatory, concentrating on past and present symptoms and conditions for urinary, bowel, sexual, and neurological functions, and on general conditions that might impair any of these.	A
Special attention should be paid to the possible existence of alarm signs, such as pain, infection, haematuria, fever, etc, that warrant further specific diagnosis.	A
A specific history should be taken for each of the four mentioned	A
Physical examination	A
Individual patient handicaps should be acknowledged in planning further investigations.	A
The neurological status should be described as completely as possible. Sensations and reflexes in the urogenital area must all be tested.	A
The anal sphincter and pelvic floor functions must be tested extensively.	A
Urinalysis, blood chemistry, voiding diary, residual and free flowmetry, incontinence quantification and urinary tract imaging should be performed.	A

** All grade A recommendations based on panel consensus.*

3.6 Urodynamics

3.6.1 *Introduction*

Urodynamic investigation is the only method that can objectively assess the (dys-)function of the LUT. It is essential to describe the LUT status in patients with NLUTD. In these patients, particularly when DO might be present, the invasive urodynamic investigation is even more provocative than in other patients. Any technical source of artefacts must be critically considered. The quality of the urodynamic recording and its interpretation must be ensured (17).

In patients at risk for autonomic dysreflexia, it is advisable to measure blood pressure during the urodynamic study.

In many patients with NLUTD, it may be helpful to assess the maximum anaesthetic bladder capacity. The rectal ampulla should be empty of stool before the start of the investigation. Drugs that influence the LUT function should be stopped at least 48 hours before the investigation (if feasible) or otherwise be considered when interpreting the data obtained.

All urodynamic findings must be reported in detail and performed according to the ICS technical recommendations and standards (17-19).

3.6.2 *Urodynamic tests*

A bladder diary is a semi-objective qualification of the LUT. It is a highly advisable diagnostic tool. For reliable interpretation, it should be recorded over at least 2-3 days (18,20). Possible pathological findings: high voiding frequency, very low or very high voided volumes, nocturnal voidings, urgency, incontinence.

Free uroflowmetry and assessment of residual urine gives a first impression of the voiding function. It is mandatory before planning any invasive urodynamics. For reliable information, it should be repeated at least 2-3 times (18,21,22). Possible pathological findings: low flow rate, low voided volume, intermittent flow, hesitancy, residual urine.

Care must be taken when assessing the results in patients who are not able to void in a normal position. Both the flow pattern and the flow rate may be modified by inappropriate positions and by any constructions to divert the flow.

Filling cystometry: The only method to quantify the filling function has limited significance as a solitary procedure. It is much more powerful if combined with bladder pressure measurement during micturition and even more in video-urodynamics. This investigation is necessary to document the status of the LUT function during the filling phase. The bladder should be empty at the start of filling. A physiological filling rate should be used with body-warm saline, as fast filling and room-temperature saline are provocative (18).

Possible pathological findings include DO, low detrusor compliance, abnormal bladder and other sensations, incontinence, incompetent or relaxing urethra.

Detrusor leak point pressure (DLPP): This specific investigation may estimate the risk for the upper urinary tract or for secondary bladder damage (18,23). The DLPP is a screening test only, because it gives no impression of

the duration of the high pressure during the filling phase, which can be expected to have even more impact on the upper urinary tract (24). A high DLPP thus warrants further testing by video-urodynamics.

Pressure flow study: This measurement reflects the co-ordination between detrusor and urethra or pelvic floor during the voiding phase. It is even more powerful in combination with filling cystometry and with video urodynamics. It is necessary to document the function of the LUT function during the voiding phase. Possible pathological findings: Detrusor underactivity/acontractility, DSD, non-relaxing urethra, residual urine.

Most types of obstruction caused by NLUTD are due to DSD (25,26), non-relaxing urethra, or non-relaxing bladder neck (18,27,28). Pressure-flow analysis mostly assesses the amount of mechanical obstruction caused by the urethra's inherent mechanical and anatomical properties and has limited value in patients with NLUTD.

Electromyography (EMG): Registration of the activity of the external urethral sphincter, the peri-urethral striated musculature, the anal sphincter, or the striated pelvic floor muscles. The correct interpretation may be difficult due to artefacts introduced by other equipment used. In the urodynamic setting an EMG is useful as a gross indication of the patient's ability to control the pelvic floor. Possible pathological findings: Inadequate recruitment on specific stimuli (bladder filling, hyperreflexive contractions, onset of voiding, coughing, Valsalva, etc.). More detailed analysis (motor unit potentials, single-fibre EMG) is only possible as part of a neurophysiological investigation.

Urethral pressure measurement: This investigation has only a very limited place in NLUTD. There exists no basic consensus on parameters indicating pathological findings (29).

Video-urodynamics: This combination of filling cystometry and pressure flow study with imaging is the gold standard for urodynamic investigation in NLUTD (18,30,31). Possible pathological findings: All as described under cystometry and pressure flow study, plus morphological pathology of the LUT and the upper urinary tract.

Ambulatory urodynamics: Functional investigation of the urinary tract utilising predominantly natural filling of the urinary tract and reproducing normal subject activity (32).

This type of study should be considered when office urodynamics do not reproduce the patient's symptoms and complaints. Possible pathological findings include those found under filling cystometry and pressure flow study, provided the flow is measured also. It should be kept in mind that during this study the actual bladder volume is unknown.

Provocative tests during urodynamics: The LUT function can be provoked by coughing, triggered voiding, or anal stretch.

Fast-filling cystometry with cooled saline (the 'ice water test') is considered a discriminative test between upper motor neuron lesion (UMNL) and lower motor neuron lesion (LMNL) (33-38). Patients with UMNL will develop a detrusor contraction if the detrusor muscle is intact, while patients with lower lesions will not. The test gives false-positive results in young children (35) and does not seem to be fully discriminative in other patients (36,37).

It was thought that a positive bethanechol test (39) (detrusor contraction > 25 cm H_2O) provided proof of a detrusor denervation hypersensitivity and the muscular integrity of an acontractile detrusor; however, in practice, the test has given equivocal results. Recently, a variation of this method was reported using intravesical electromotive administration of the bethanechol (40); this test turned out to be both selective and predictive for successful oral bethanechol treatment.

3.6.3 ***Specific uro-neurophysiological tests***

These tests are advised as part of the neurological work-up of the patient. They comprise:

- EMG (in a neurophysiological setting) of pelvic floor muscles, urethral sphincter and/or anal sphincter;
- nerve conduction studies of pudendal nerve;
- reflex latency measurements of bulbocavernosus and anal reflex arcs;
- evoked responses from clitoris or glans penis;
- sensory testing on bladder and urethra.

Other elective tests may be asked for specific conditions that became obvious during patient work-up and urodynamic investigations. Possible pathological findings are dependent on the type of the test.

3.6.4 *Recommendations for urodynamics and uro-neurophysiology*

Recommendations	GR
Urodynamic investigation is necessary to document the (dys-)function of the LUT.	A
The recording of a bladder diary is advisable.	B
Non-invasive testing is mandatory before invasive urodynamics is planned.	A
Video-urodynamics is the gold standard for invasive urodynamics in patients with NLUTD. If this is not available, then a filling cystometry continuing into a pressure flow study should be performed.	A
A physiological filling rate and body-warm saline must be used.	A
Specific uro-neurophysiological tests are elective procedures.	C

3.7 *Typical manifestations of neurogenic lower urinary tract dysfunction*

Typical findings in NLUTD are listed below:

Filling phase

- hyposensitivity or hypersensitivity;
- vegetative sensations;
- low compliance;
- high capacity bladder;
- detrusor overactivity, spontaneous or provoked;
- sphincter acontractility.

Voiding phase

- detrusor acontractility;
- DSD;
- non-relaxing urethra;
- non-relaxing bladder neck.

These signs warrant further neurological evaluation, as LUTD may be the presenting symptom of NLUTD (41-45).

3.8 References

1. Madersbacher H. The various types of neurogenic bladder dysfunction: an update of current therapeutic concepts. Paraplegia 1990 May;28(4):217-29. http://www.ncbi.nlm.nih.gov/pubmed/2235029
2. Satar N, Bauer SB, Shefner J, et al. The effects of delayed diagnosis and treatment in patients with an occult spinal dysraphism. J Urol 1995 Aug;154(2 Pt 2):754-8. http://www.ncbi.nlm.nih.gov/pubmed/7609171
3. Watanabe T, Vaccaro AR, Kumon H, et al. High incidence of occult neurogenic bladder dysfunction in neurologically intact patients with thoracolumbar spinal injuries. J Urol 1998 Mar;159(3):965-8. http://www.ncbi.nlm.nih.gov/pubmed/9474194
4. Bemelmans BL, Hommes OR, Van Kerrebroeck PE, et al. Evidence for early lower urinary tract dysfunction in clinically silent multiple sclerosis. J Urol 1991 Jun;145(6):1219-24. http://www.ncbi.nlm.nih.gov/pubmed/2033697
5. Ahlberg J, Edlund C, Wikkelsö C, et al. Neurological signs are common in patients with urodynamically verified “idiopathic” bladder overactivity. Neurourol Urodyn 2002;21(1):65-70. http://www.ncbi.nlm.nih.gov/pubmed/11835426
6. Weld KJ, Graney MJ, Dmochowski RR. Differences in bladder compliance with time and associations of bladder management with compliance in spinal cord injured patients. J Urol 2000 Apr;163(4): 1228-33. http://www.ncbi.nlm.nih.gov/pubmed/10737503
7. Bors E, Turner RD. History and physical examination in neurological urology. J Urol 1960 May;83: 759-67. [no abstract available] http://www.ncbi.nlm.nih.gov/pubmed/13802958
8. Jayawardena V, Midha M. Significance of bacteriuria in neurogenic bladder. J Spinal Cord Med 2004;27(2):102-5. http://www.ncbi.nlm.nih.gov/pubmed/15162878
9. Massa LM, Hoffman JM, Cardenas DD. Validity, accuracy, and predictive value of urinary tract infection signs and symptoms in individuals with spinal cord injury on intermittent catheterization. J Spinal Cord Med 2009;32(5):568-73. http://www.ncbi.nlm.nih.gov/pubmed/20025153

10. Linsenmeyer TA, Oakley A. Accuracy of individuals with spinal cord injury at predicting urinary tract infections based on their symptoms. J Spinal Cord Med 2003 Winter;26(4):352-7. http://www.ncbi.nlm.nih.gov/pubmed/14992336
11. Stöhrer M, Goepel M, Kondo A, et al. The standardization of terminology in neurogenic lower urinary tract dysfunction: with suggestions for diagnostic procedures. International Continence Society Standardization Committee. Neurourol Urodyn 1999;18(2):139-58. http://www.ncbi.nlm.nih.gov/pubmed/10081953
12. Naoemova I, De Wachter S, Wuyts FL, et al. Reliability of the 24-h sensation-related bladder diary in women with urinary incontinence. Int Urogynecol J Pelvic Floor Dysfunct 2008 Jul;19(7):955-9. http://www.ncbi.nlm.nih.gov/pubmed/18235981
13. Honjo, H, Kawauchi A, Nakao M, et al. Impact of convenience void in a bladder diary with urinary perception grade to assess overactive bladder symptoms: a community-based study. Neurourol Urodyn 2010 Sep;29(7):1286-9. http://www.ncbi.nlm.nih.gov/pubmed/20878998
14. Braddom RL, Rocco JF. Autonomic dysreflexia. A survey of current treatment. Am J Phys Med Rehabil 1991 Oct;70(5):234-41. http://www.ncbi.nlm.nih.gov/pubmed/1910647
15. Silver JR. Early autonomic dysreflexia. Spinal Cord 2000 Apr;38(4):229-33. http://www.ncbi.nlm.nih.gov/pubmed/10822393
16. Assadi F, Czech K, Palmisano JL. Autonomic dysreflexia manifested by severe hypertension. Med Sci Monit 2004 Dec;10(12):CS77-9. http://www.ncbi.nlm.nih.gov/pubmed/15567988
17. Schurch B. The predictive value of plantar flexion of the toes in the assessment of neuropathic voiding disorders in patients with spine lesions at the thoracolumbar level. Arch Phys Med Rehabil 1999 Jun;80(6):681-6. http://www.ncbi.nlm.nih.gov/pubmed/10378495
18. Stöhrer M, Goepel M, Kondo A, et al. The standardization of terminology in neurogenic lower urinary tract dysfunction with suggestions for diagnostic procedures. International Continence Society Standardization Committee. Neurourol Urodyn 1999;18(2):139-58. http://www.ncbi.nlm.nih.gov/pubmed/10081953
19. Ochoa B. Can a congenital dysfunctional bladder be diagnosed from a smile? The Ochoa syndrome updated. Pediatr Nephrol 2004 Jan;19(1):6-12. http://www.ncbi.nlm.nih.gov/pubmed/14648341
20. Reynard JM, Peters TJ, Lim C, et al. The value of multiple free-flow studies in men with lower Urinary tract symptoms. Br J Urol 1996 Jun;77(6):813-8. http://www.ncbi.nlm.nih.gov/pubmed/8705213
21. Weld KJ, Dmochowski RR. Association of level of injury and bladder behavior in patients with post-traumatic spinal cord injury. Urology 2000 Apr;55(4):490-4. http://www.ncbi.nlm.nih.gov/pubmed/10736489
22. Schurch B, Schmid DM, Kaegi K. Value of sensory examination in predicting bladder function in patients with T12-L1 fractures and spinal cord injury. Arch Phys Med Rehabil 2003 Jan;84(1):83-9. http://www.ncbi.nlm.nih.gov/pubmed/12589626
23. Sonke GS, Kiemeney LA, Verbeek AL, et al. Low reproducibility of maximum urinary flow rate determined by portable flowmetry. Neurourol Urodyn 1999;18(3):183-91. http://www.ncbi.nlm.nih.gov/pubmed/10338438
24. Schäfer W, Abrams P, Liao L, et al. International Continence Society. Good urodynamic practices: uroflowmetry, filling cystometry, and pressure-flow studies. Neurourol Urodyn 2002;21(3):261-74. http://www.ncbi.nlm.nih.gov/pubmed/11948720
25. 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(2):167-78. http://www.ncbi.nlm.nih.gov/pubmed/11857671
26. Homma Y, Ando T, Yoshida M, et al. Voiding and incontinence frequencies: variability of diary data and required diary length. Neurourol Urodyn 2002;21(3):204-9. http://www.ncbi.nlm.nih.gov/pubmed/11948713
27. McGuire EJ, Cespedes RD, O'Connell HE. Leak-point pressures. Urol Clin North Am 1996 May;23(2): 253-62. http://www.ncbi.nlm.nih.gov/pubmed/8659025

28. Linsenmeyer TA, Bagaria SP, Gendron B. The impact of urodynamic parameters on the upper tracts of spinal cord injured men who void reflexly. J Spinal Cord Med 1998 Jan;21(1):15-20. http://www.ncbi.nlm.nih.gov/pubmed/9541882
29. Krongrad A, Sotolongo JR Jr. Bladder neck dysynergia in spinal cord injury. Am J Phys Med Rehabil 1996 May-Jun;75(3):204-7. http://www.ncbi.nlm.nih.gov/pubmed/8663928
30. Weld KJ, Graney MJ, Dmochowski RR. Clinical significance of detrusor sphincter dyssynergia type in patients with post-traumatic spinal cord injury. Urology 2000 Oct;56(4):565-8. http://www.ncbi.nlm.nih.gov/pubmed/11018603
31. Rossier AB, Fam BA. 5-microtransducer catheter in evaluation of neurogenic bladder function. Urology 1986 Apr;27(4):371-8. http://www.ncbi.nlm.nih.gov/pubmed/3962062
32. Al-Ali M, Haddad L. A 10 year review of the endoscopic treatment of 125 spinal cord injured patients with vesical outlet obstruction: does bladder neck dyssynergia exist? Paraplegia 1996 Jan;34(1): 34-38. http://www.ncbi.nlm.nih.gov/pubmed/8848321
33. Lose G, Griffiths D, Hosker G, et al. Standardization Sub-Committee, International Continence Society. Standardisation of urethral pressure measurement: report from the Standardisation Sub-Committee of the International Continence Society. Neurourol Urodyn 2002;21(3):258-60. http://www.ncbi.nlm.nih.gov/pubmed/11948719
34. Rivas DA, Chancellor MB. Neurogenic vesical dysfunction. Urol Clin North Am 1995 Aug;22(3):579-91. http://www.ncbi.nlm.nih.gov/pubmed/7645158
35. Madersbacher HG. Neurogenic bladder dysfunction. Curr Opin Urol 1999 Jul;9(4):303-7. http://www.ncbi.nlm.nih.gov/pubmed/10459465
36. van Waalwijk van Doorn E, Anders K, Khullar V, et al. Standardisation of ambulatory urodynamic monitoring: report of the Standardisation Sub- Committee of the International Continence Society for Ambulatory Urodynamic Studies. Neurourol Urodyn 2000;19(2):113-25. http://www.ncbi.nlm.nih.gov/pubmed/10679828
37. Geirsson G, Fall M, Lindström S. The ice-water test-a simple and valuable supplement to routine cystometry. Br J Urol 1993 Jun;71(6):681-5. http://www.ncbi.nlm.nih.gov/pubmed/8343894
38. Geirsson G, Lindström S, Fall M. Pressure, volume and infusion speed criteria for the ice-water test. Br J Urol 1994 May;73(5):498-503. http://www.ncbi.nlm.nih.gov/pubmed/8012770
39. Geirsson G, Lindström S, Fall M, et al. Positive bladder cooling test in neurologically normal young children. J Urol 1994 Feb;151(2):446-8. http://www.ncbi.nlm.nih.gov/pubmed/8283555
40. Petersen T, Chandiramani V, Fowler CJ. The ice-water test in detrusor hyper-reflexia and bladder instability. Br J Urol 1997 Feb;79(2):163-7. http://www.ncbi.nlm.nih.gov/pubmed/9052463
41. Chancellor MB, Lavelle J, Ozawa H, et al. Ice-water test in the urodynamic evaluation of spinal cord injured patients. Tech Urol 1998 Jun;4(2):87-91. http://www.ncbi.nlm.nih.gov/pubmed/9623622
42. Ronzoni G, Menchinelli P, Manca A, et al. The ice-water test in the diagnosis and treatment of the neurogenic bladder. Br J Urol 1997 May;79(5):698-701. http://www.ncbi.nlm.nih.gov/pubmed/9158504
43. Lapides J. Neurogenic bladder. Principles of treatment. Urol Clin North Am 1974 Feb;1(1):81-97. [no abstract available] http://www.ncbi.nlm.nih.gov/pubmed/4428540
44. Riedl CR, Stephen RL, Daha LK, et al. Electromotive administration of intravesical bethanechol and the clinical impact on acontractile detrusor management: introduction of a new test. J Urol 2000 Dec;164(6):2108-11. http://www.ncbi.nlm.nih.gov/pubmed/11061937
45. Bemelmans BL, Hommes OR, Van Kerrebroeck PE, et al. Evidence for early lower urinary tract dysfunction in clinically silent multiple sclerosis. J Urol 1991 Jun;145(6):1219-24. http://www.ncbi.nlm.nih.gov/pubmed/2033697

4. TREATMENT

4.1 Introduction

The primary aims for treatment of NLUTD and their priorities are (1-4):

1. Protection of the upper urinary tract.
2. Improvement of urinary continence.
3. Restoration of (parts of) the LUT function.
4. Improvement of the patient's QoL.

Further considerations are the patient's disability, cost-effectiveness, technical complexity, and possible complications (4).

Preservation of the upper tract function is of paramount importance (1-7). Renal failure was the main factor for mortality in the SCI patient surviving the trauma (5-7). This has led to the golden rule in treatment of NLUTD: ensure that the detrusor pressure remains within safe limits during both the filling phase and the voiding phase (1-4). This approach has indeed significantly reduced the mortality from urological causes in this patient group (8).

The therapy of urinary incontinence is important for social rehabilitation of the patient and thus contributes substantially to the QoL. It is also pivotal in preventing UTI (6,7). If complete continence cannot be achieved, methods to attain a socially acceptable control of incontinence can be used.

The patient's QoL is an essential part of any treatment decision.

In patients with high detrusor pressure during the filling phase (DO, low detrusor compliance) or during the voiding phase (DSD, other causes of bladder outlet obstruction), treatment is aimed primarily at 'conversion of an active, aggressive high-pressure bladder into a passive low-pressure reservoir' despite the resulting residual urine (1).

4.2 Non-invasive conservative treatment

*4.2.1 **Assisted bladder emptying***

Incomplete bladder emptying is a serious risk factor for UTI, developing a high intravesical pressure during the filling phase, and incontinence. Methods to improve the voiding process are practised in patients with NLUTD.

Third party bladder expression (Credé): Regretfully, this method is still applied, foremost in infants and young children with myelomeningocele and sometimes in tetraplegics. Because of the high pressures that may be created during this procedure, it is potentially hazardous for the urinary tract (9).

Voiding by abdominal straining (Valsalva): The considerations mentioned under Credé above also apply to the Valsalva manoeuvre (1,9-11). For both methods of emptying, long-term complications are hardly avoidable (9,10) and the already weak pelvic floor function may be further impaired, thus exacerbating the existing incontinence (11).

Triggered reflex voiding: Stimulation of the sacral or lumbar dermatomes in patients with UMNL can elicit reflex contraction of the detrusor (1,11). Morbidity occurs more often during the first decades of treatment (12-16). Strict urodynamic control is therefore required (1,11).

Behavioural modification techniques: These are used to improve continence and include prompted voiding, timed voiding (bladder training), and lifestyle modification (17-20).

Pelvic floor muscle exercises: These aim to improve continence. They may be helpful in selected patients with NLUTD (21-23).

Biofeedback: This method can be used for supporting the voiding pattern modification (24,25).

*4.2.2 **Lower urinary tract rehabilitation***

4.2.2.1 Bladder rehabilitation including electrical stimulation

4.2.2.1.1 Introduction

The term bladder rehabilitation summarises treatment options that aim to re-establish bladder function in patients with NLUTD. Regaining voluntary control over LUTD has been described in individuals with non-neurogenic bladder dysfunction, using behavioural treatment in patients with urge incontinence and biofeedback training for stress urinary incontinence. However, evidence for bladder rehabilitation using electrical stimulation in neurogenic patients is lacking and mainly based on pilot studies with small patient numbers.

A strong contraction of the urethral sphincter and/or pelvic floor, but also anal dilatation, manipulation of the genital region, and physical activity reflexly inhibit the micturition (11,26). Whereas the first mechanism is affected by activation of efferent fibres, the latter ones are produced by activation of afferents (14). Electrical stimulation of the pudendal nerve afferents produces a strong inhibition of the micturition reflex and of the detrusor contraction (27). This stimulation might then support the restoration of the balance between excitatory and inhibitory inputs at the spinal or supraspinal level (11,28,29). It might also imply that patients with incomplete lesions will benefit (11,29,30), but patients with complete lesions will not (31).

4.2.2.1.2 Peripheral temporary electrostimulation
Posterior tibial nerve stimulation and external temporary electrical stimulation (e.g. penile/clitoral or intracavital) suppress neurogenic DO during acute stimulation (32). Both techniques have also demonstrated sustained prolonged effects (3 months and 1 year, respectively) in patients with neurogenic bladder dysfunction due to MS (33.34).

In MS patients, combining active neuromuscular electrical stimulation with pelvic floor muscle training and electromyography biofeedback achieved a substantial reduction of LUTD (35). Furthermore, this treatment combination was significantly superior ($p = 0.0028$) to electrostimulation alone.

Biofeedback: This method can be used for supporting the voiding pattern modification (24,25).

4.2.2.1.3 Intravesical electrostimulation
Intravesical electrostimulation can increase bladder capacity, improve bladder compliance as well as the sensation of bladder filling in patients with incomplete SCI or meningomyelocele (36). In patients with neurogenic detrusor hypocontractility, intravesical electrostimulation may also improve voiding and reduce residual urine volume (37).

4.2.2.1.4 Chronic peripheral pudendal stimulation
The results of a pilot study showed that chronic peripheral pudendal stimulation (chronic, defined as a period of 2 weeks) in patients with incomplete SCI produced significant neuromodulatory effects in the brain which led to changes in urodynamic parameters (38).

4.2.2.1.5 Repetitive transcranial magnetic stimulation
Although repetitive transcranial magnetic stimulation improved voiding symptoms in patients with PD or MS, the duration of the effect, stimulation parameters and the appropriate patient selection are still under investigation (39,40).

4.2.2.1.6 Summary
To date, bladder rehabilitation techniques are mainly based on electrical or magnetic stimulation. However, there is a lack of well-designed studies for all techniques. The different techniques of external temporary electrostimulation, possibly combined with biofeedback training, may be useful, especially in patients with MS or incomplete spinal cord injury. Further studies are necessary to evaluate the usefulness of these techniques.

4.2.3 ***Drug treatment***
A single, optimal, medical therapy for NLUTD is not yet available. Currently, a combination of therapies is the best way to maximise outcomes (41-50) (LE: 1a).

4.2.3.1 Antimuscarinic drugs
Antimuscarinic drugs are the first-line choice for treating NLUTD. They are the most useful medications available for NLUTD and provide an established approach to managing neurogenic detrusor overactivity (NDO) (41-47,51-53) (LE: 1a). Previously, these drugs were known as ‘anticholinergic’, but they are now described as muscarinic receptor antagonists because of their action in binding to muscarinic receptors. Antimuscarinic drugs are used to stabilise the detrusor muscle, which reduces its overactivity and makes it moderately refractory to parasympathetic stimulation. This results in improved bladder compliance and reduced symptoms of overactive bladder (47,51), which in turn helps to prevent renal and bladder damage and potentially improve long-term outcomes (54) (LE: 1a).

Neurogenic patients may need a higher dose of antimuscarinic agents than patients with idiopathic DO (47,48,55-57) (LE: 1b). However, adverse events due to the higher dosage may lead to early discontinuation of therapy (19,21,56,58,59) (LE: 1b).

4.2.3.1.1 Choice of antimuscarinic agent

Oxybutynin chloride (47) (LE: 1a) (48-51,57-59), trospium chloride (47,55,56,60), tolterodine tartrate (61-63) and propiverine (47,58,64,65) (LE: 1a) are established, effective, medical treatments. These antimuscarinic agents are known to be well tolerated and safe, even during long-term treatment. They have diverse tolerance profiles, so that a different antimuscarinic agent may be prescribed if a patient experiences adverse effects or if the therapeutic effect is not sufficient (66).

Darifenacin has recently been evaluated in neurogenic overactive bladder secondary to MS (67,68), with results similar to other muscarinic drugs. Solifenacin has also been introduced, even though to date there has been no published clinical evidence of the use of solifenacin in NDO. Data is awaited from an ongoing trial.

4.2.3.1.1.1 Side-effects

Antimuscarinic agents have some minor side-effects, e.g. dry mouth. It has been suggested that different ways of administration may help to reduce side-effects. In a selected group of patients, transdermal oxybutynin was found to be well tolerated and effective (69,70), while intravesical oxybutynin led to abolishment of the bladder-cooling reflex (71). However, further research is needed into the use of alternative methods of administration, particularly long-term results (LE: 2a).

4.2.3.2 Other agents

4.2.3.2.1 Phosphodiesterase inhibitors (PDE5Is)

These have demonstrated significant effects upon DO in pilot studies and in the future may become an alternative or adjunct to antimuscarinic treatment (72).

4.2.3.3 Adjunct desmopressin

Additional treatment with desmopressin might improve the efficacy of treatment (73-75) (LE: 3).

4.2.3.4 Drugs with different mechanisms of action

4.2.3.4.1 Detrusor underactivity

Cholinergic drugs, such as bethanechol chloride and distigmine bromide, have been considered to enhance detrusor contractility and promote bladder emptying, but are not routinely used in clinical practice. The available studies do not support the use of parasympathomimetic agents, especially when frequent and/or serious possible side-effects are considered (76) (LE: 1a).

Combination therapy with an antimuscarinic drug and alpha-blocker appears to be more useful than monotherapy with either agent (77). In conclusion, there is no drug with evidence of efficacy for underactive detrusor (11,78-81) (LE: 2a).

4.2.3.4.2 Decreasing bladder outlet resistance

Alpha-blockers (non-selective and selective) have been partially successful for decreasing bladder outlet resistance, residual urine and autonomic dysreflexia (11,82-86) (LE: 2a).

4.2.3.4.3 Increasing bladder outlet resistance

Several drugs have shown efficacy in selected cases of mild stress urinary incontinence, but there have been very few publications in patients with NLUTD (11,87).

4.2.3.4.4 Conclusions and recommendations on drug treatments

Conclusions	**LE**
Long-term efficacy and safety of antimuscarinic therapy for NDO is well documented.	1a
A combination of antimuscarinic agents is now used more frequently and is often considered to maximise outcomes for NDO.	1a
Alternative ways of administration of antimuscarinic agents, such as transdermally and intravesically, should now be considered.	2a
There is no drug with evidence of efficacy for underactive detrusor.	2a
Alpha-blockers have been partly successful in decreasing bladder outlet resistance and autonomic dysreflexia prophylaxis in spinal cord injury.	2a
There is a lack of prospective, randomised, controlled studies in the medical management of NLUTD.	

Recommendations on drug treatments	GR
Antimuscarinic therapy for NDO is effective and safe to use, also long term.	A
Outcomes for NDO can be maximised by considering a combination of antimuscarinic agents.	A
Alternative ways of administration of antimuscarinic agents, such as transdermally and intravesically, should be considered with the aim of reducing side-effects.	B
Alpha-blockers may help to decrease bladder outlet resistance and may be a preventive measure in spinal cord injury to prevent autonomic dysreflexia.	B

NDO = neurogenic detrusor overactivity.

*4.2.4 **External appliances***

As an ultimate remedy, social continence may be achieved by collecting urine during incontinence (1,11). Condom catheters with urine collection devices are a practical method for men. Otherwise, incontinence pads may offer a reliable solution. In both cases, the infection risk must be closely observed (11). Because of the risk of developing high intravesical pressure, the penile clamp is absolutely contraindicated.

*4.2.5 **Statements & guidelines on non-invasive conservative treatment***

Statements	LE
The first aim of any therapy is the protection of the upper urinary tract.	1
A condom catheter or pads may reduce urinary incontinence to a socially acceptable situation.	

Recommendations	GR
The mainstay of treatment for overactive detrusor is anticholinergic drug therapy.	A
Lower urinary tract rehabilitation may be effective in selected cases (patients that do not suffer from a complete spinal cord lesion).	
Any method of assisted bladder emptying should be used with the greatest caution.	A

4.3 Minimal invasive treatment

*4.3.1 **Catheterisation***

Intermittent self- or third-party catheterisation (88,89) is the gold standard for the management of NLUTD (1,11). It is effective in patients with:

- Detrusor underactivity or acontractility (1).
- With DO, provided the overactivity can be controlled (1,11,90-95).

Sterile IC, as originally proposed by Guttmann and Frankel (67), significantly reduces the risk of UTI and/or bacteriuria (1,11,96,97), compared with clean IC introduced by Lapides, et al. (89). However, it cannot be considered a routine procedure (11,97). Aseptic IC is an alternative (1,98), which provides a significant benefit in reducing the potential for external contamination of an intermittent urinary catheter (99). Insufficient patient education and the inherent greater risk of UTI in patients with NLUTD are contributing factors (11,100-104).

The average frequency of catheterisations per day is 4-6 times and the catheter size should be 12-14 Fr. Less frequent catheterisation results in higher catheterisation volumes and a higher risk of UTI (1,100-103). More frequent catheterisation increases the risk of cross-infections and other complications (1,100-103). Bladder volume at catheterisation should be lower than 400 mL.

The prevalence of complications can be limited by adequate patient education, use of nontraumatising techniques and adequate precautions to prevent infections (11,104).

Indwelling transurethral catheterisation and, to a lesser extent, suprapubic cystostomy are significant and early risk factors for UTI and other complications (11,16,105-114). Silicone catheters are preferred because they are less susceptible to encrustation and because of the high incidence of latex allergy in the NLUTD population.

4.3.2 ***Recommendations for catheterisation***

Recommendations	GR
Intermittent catheterisation is the standard treatment for patients who are unable to empty their bladder.	A
Patients should be well instructed in the technique and risks of IC.	
Aseptic IC is the method of choice.	B
The catheter size should be 12-14 Fr.	B
The frequency of IC is 4-6 times per day.	B
The bladder volume should remain below 400 mL.	B
Indwelling transurethral and suprapubic catheterisation should be used only exceptionally, under close control, and the catheter should be changed frequently. Silicone catheters are preferred and should be changed every 2-4 weeks, while (coated) latex catheters need to be changed every 1-2 weeks.	A

IC = intermittent catheterisation.

4.3.3 ***Intravesical drug treatment***

To reduce DO, anticholinergics can also be applied intravesically (115-121). This approach may reduce adverse effects because the anticholinergic drug is metabolised differently (119) and a greater amount is sequestered in the bladder, even more than with electromotive administration (120,121).

The vanilloids, capsaicin and resiniferatoxin, desensitise the C-fibres and thereby decrease DO for a period of a few months until the sensation of these fibres has been restored (122-127).
The dosage is 1-2 mMol capsaicin in 100 mL 30% alcohol, or 10-100 nMol resiniferatoxin in 100 mL 10% alcohol for 30 minutes. Resiniferatoxin has about a 1,000-fold potency compared to capsaicin, with less pain during the instillation, and is effective in patients refractory to capsaicin. Clinical studies have shown that resiniferatoxin has limited clinical efficacy compared to botulinum toxin A injections in the detrusor (127).

4.3.4 ***Intravesical electrostimulation***

Intravesical electrostimulation (128) enhances the sensation for bladder filling and urge to void and may restore the volitional control of the detrusor (11,129,130). Daily stimulation sessions of 90 minutes with 10 mApulses of 2 ms duration at a frequency of 20 Hz (130,131) are used for at least 1 week (131). It appears that patients with peripheral lesions are the best candidates, that the detrusor muscle must be intact, and that at least some afferent connection between the detrusor and the brain must still be present (11,130,131). Also, the positioning of the stimulating electrodes and bladder filling are important parameters (132). With these precautions, the results in the literature are still not unequivocal: both positive (129,131,133,134) and negative (LE: 3) (135,136) results have been reported.

4.3.5 ***Botulinum toxin injections in the bladder***

Botulinum toxin causes a long-lasting but reversible chemical denervation that lasts for about 9 months (137-143). The toxin injections are mapped over the detrusor in a dosage that depends on the preparation used. Botulinum toxin A has been proven effective in a randomised placebo-controlled trial in NLUTD (144). Repeated injections seem to be possible without loss of efficacy (143,145,146). Generalised muscular weakness is an occasional adverse effect (141,143,146). Histological studies have not found ultrastructural changes after injection (147).

4.3.6 ***Bladder neck and urethral procedures***

Reduction of the bladder outlet resistance may be necessary to protect the upper urinary tract. This can be achieved by surgical interventions (bladder neck or sphincter incision or urethral stent) or by chemical denervation of the sphincter. Incontinence may result and can be managed by external devices (see Section 4.2.5).

Botulinum toxin sphincter injection can be used to treat detrusor sphincter dyssynergia effectively by injection in a dosage that depends on the preparation used. The dyssynergia is abolished for a few months, necessitating repeat injections. The efficacy of this treatment is high and there are few adverse effects (148-150).

Balloon dilatation: although favourable immediate results were reported (151), no further reports since 1994 have been found. Consequently, this method is no longer recommended.

Sphincterotomy: by staged incision, bladder outlet resistance can be reduced without completely losing the closure function of the urethra (1,11,144). The laser technique appears to be advantageous (1,152).

Sphincterotomy also needs to be repeated at regular intervals in a substantial proportion of patients (153), but is efficient and without severe adverse effects (1,9,151-154). Secondary narrowing of the bladder neck may occur, for which combined bladder neck incision might be considered (1,155).

Bladder neck incision: This is indicated only for secondary changes at the bladder neck (fibrosis) (1,9,152,155). When the detrusor is hypertrophied and causes thickening of the bladder neck, this procedure makes no sense (1).

Stents: Implantation of urethral stents causes the continence to be dependent on the adequate closure of the bladder neck only (1,4). Although the results are comparable with sphincterotomy and the stenting procedure has a shorter surgery time and reduced hospital stay (156,157), the costs (1) and possible complications or re-interventions (156,158,159) are limiting factors in its use.

Increasing bladder outlet resistance: This can improve the continence condition. Despite early positive results with urethral bulking agents, a relative early loss of continence is reported in patients with NLUTD (4,16,160-164).

Urethral inserts: Urethral plugs or valves for management of (female) stress incontinence have not been applied in patients with NLUTD. The experience with active pumping urethral prosthesis for treatment of the underactive or acontractile detrusor was disappointing (165).

4.3.7 ***Recommendations for minimal invasive treatment****

Recommendations	GR
Botulinum toxin injection in the detrusor is the most effective minimally invasive treatment to reduce neurogenic detrusor overactivity.	A
Sphincterotomy is the standard treatment for detrusor sphincter dyssynergia.	A
Bladder neck incision is effective in a fibrotic bladder neck.	B

**Guidelines for catheterisation are listed separately under Section 4.3.2.*

4.4 Surgical treatment

4.4.1 ***Urethral and bladder neck procedures***

Increasing the bladder outlet resistance has the inherent risk of causing high intravesical pressure during the filling, which may become even higher during the voiding phase. Procedures to treat sphincteric incontinence are suitable only when the detrusor activity is, or can be, controlled, when no significant reflux is present.

Moreover, these procedures require the urethra and bladder neck to be in good condition and mostly result in intermittent catheterisation being performed after the procedure (4).

Urethral sling: Various materials have been used for this procedure with enduring positive results (4,166-179). The procedure is established in women; for men, the artificial sphincter is obviously the first choice (4).

Artificial urinary sphincter: This device has stood the test of time in patients with NLUTD (4). It was introduced by Light and Scott (180) for this patient group and the need for revisions (181) has decreased significantly with new generations of devices (172,182-185).

Functional sphincter augmentation: By transposing the gracilis muscle to the bladder neck (186) or to the proximal urethra (187), the possibility exists for creating a functional autologous sphincter by electrical stimulation (186,187). This would open the possibility of restoring control over the urethral closure.

Bladder neck and urethra reconstruction: The classical Young-Dees-Leadbetter (188) procedure for bladder neck reconstruction in children with bladder exstrophy and the Kropp urethral lengthening (189) improved by Salle (190) are established methods to restore continence provided that intermittent catheterisation is practiced and/or bladder augmentation is performed (172,181,189-200).

4.4.2 ***Detrusor myectomy (auto-augmentation)***

The idea of enlarging a shrunken bladder by removing lateral detrusor tissue to free the entrapped ureter in a non-functional fibrotic detrusor was put forward by Couvelaire (201). Since its clinical introduction by

Cartwright and Snow (202) in children and by Stöhrer (203) in adults, this procedure for reducing DO or improving low detrusor compliance has gained popularity because of its acceptable long-term results, its low surgical burden, its low rate of long-term adverse effects, its positive effect on the patient's QoL, and because it does not preclude further interventions (1,4,202-221).

The procedure is performed extraperitoneally under general anaesthesia and consists of the dissection of about 20% of the detrusor tissue around the umbilicus, leaving the mucosa intact (1,202,203). A diverticulum will develop, but this may take 1-2 years in adults (1,191,192). A laparoscopic procedure (205,209,213,222), covering of the mucosa at the detrusor defect (transperitoneal) (24,212,214,218), supporting the bladder (202,218), or simple incision of the detrusor muscle (detrusor myotomy) (220,221) are proposed variations of the procedure but offer no essential advantages.

*4.4.3 **Denervation, deafferentation, neurostimulation, neuromodulation***

Various procedures estimated to destroy the peripheral detrusor innervation have been abandoned because of poor long-term results and severe complications (4). These procedures include bladder distension, cytolysis, transvaginal denervation (Ingelman-Sundberg procedure) and subtrigonal phenol injections.

Sacral rhizotomy, also known as sacral deafferentation (SDAF), has achieved some success in reducing DO (16,223-227), but it is used nowadays mostly as an adjuvant to sacral anterior root stimulation (228-239). Alternatives for rhizotomy are sought in this treatment combination (240-242).

Sacral anterior root stimulation (SARS) is aimed at producing a detrusor contraction. The technique was developed by Brindley (243) and is applicable only in complete lesions above the implant location because of its stimulation amplitude over the pain threshold. The urethral sphincter efferents are also stimulated, but as the striated muscle relaxes faster than the smooth muscle of the detrusor, a so-called 'post-stimulus voiding' will occur. This approach has been successful in highly selected patients (228-239). By changing the stimulation parameters, this method can also induce defecation or erection.

The sacral nerve stimulation or sacral neuromodulation is based on the research by Schmidt and Tanagho (244). This technique stimulates the afferents and thereby probably restores the correct balance between excitatory and inhibitory impulses from and to the pelvic organs at a sacral and supra-sacral level, thus reducing the DO (28,245). It is used either as a temporary procedure using foramen electrodes with an external stimulator, with the expectation that the changes will persevere after treatment, or as a chronic procedure with an implanted stimulator. In the latter case, a test procedure, the percutaneous nerve evaluation (PNE), with an external stimulator is performed before the implant to judge the patient's response. This procedure also has considerable success in selected patients (210,246-250).

On the basis of the successful application of these systems, future developments towards a device that may be more integrated in the body are under research (251).

*4.4.4 **Bladder covering by striated muscle***

When the bladder is covered by a (part of) striated muscle that can be stimulated electrically, or ideally could be contracted volitionally, an acontractile bladder could be restored to perform a voiding function. The rectus abdominis (252) and the latissimus dorsi (253) have been used successfully in patients with NLUTD.

*4.4.5 **Bladder augmentation or substitution***

Replacing or expanding the bladder by intestine or other passive expandable coverage will reduce detrusor compliance and at least reduce the pressure effect of DO. The inherent complications associated with these procedures include recurrent infection, stone building, perforation or diverticula, possible malignant changes, and for intestine metabolic abnormality, mucus production and impaired bowel function (4,254-256). Since the age of the NLUTD patient population, when the surgery is performed, is generally much lower than that of patients with bladder malignancy, who are elected for this surgery, it is important that any possible, very long-term, complications in particular are appraised. Thus, the procedures should be used with caution in NLUTD patients, but may become necessary if all less-invasive treatment methods have failed.

Bladder augmentation, by procedures such as clam cystoplasty, is a valid option to decrease detrusor pressure and increase bladder capacity, whenever more conservative approaches have failed. A number of different techniques have been published. The results of the various procedures are very good and comparable (208,210-212,215-217,255-258). Bladder substitution to create a low pressure reservoir may be indicated in patients with severely thick and fibrotic bladder wall. Scaffolds, probably of tissue-engineered material for bladder augmentation or substitution or alternative techniques, are promising future options (216,259-264).

*4.4.6 **Urinary diversion***

When no other therapy has been successful, urinary diversion must be considered for the protection of the upper tract and for the patient's QoL (4,265).

Continent diversion: This should be the first choice for diversion. In patients for whom indwelling catheterisation or suprapubic catheterisation is the only feasible treatment option, change to a continent stoma may be a better prospect (4). Some patients with limited dexterity prefer a stoma to using the urethra for catheterisation (4). The continent stoma is created following various techniques. All of them, however, do show frequent complications, including leakage or stenosis (4,266). The short-term continence rates are over 80% and good protection of the upper urinary tract is achieved (4,13,264-278). For cosmetic reasons, the umbilicus is often used for the stoma site, but this may have a higher risk of stenosis (269,271,276).

Incontinent diversion: If catheterisation is impossible, incontinent diversion with urine collecting devices are indicated. Fortunately, nowadays, this indication is seldom because many appropriate alternatives can be offered (4). Ultimately, it could be considered in patients who are wheelchair bound or bed-ridden with intractable and untreatable incontinence, in devastated LUTs, when the upper urinary tract is severely compromised, and in patients who refuse other therapy (4). An ileal segment is used for the deviation in most cases (4,279-283). The rather poor long-term results and the expected complications warrant a permanent follow-up (4).

Undiversion: Long-standing diversions may be successfully undiverted or an incontinent diversion changed to a continent one with the emergence of new and better techniques for control of the detrusor pressure and the incontinence (4). Also, in young patients, body image may play a role (273). The patient must be carefully counselled and must comply meticulously with the instructions (4). Successful undiversion can then be performed (284).

4.5 Recommendations for surgical treatment

Recommendations			**GR**
Detrusor	Overactive	Detrusor myectomy is an acceptable option for the treatment of overactive bladder when more conservative approaches have failed. It is limited invasive and has minimal morbidity.	B
		Sacral rhizotomy with SARS in complete lesions and sacral neuromodulation in incomplete lesions are effective treatments in selected patients.	B
		Bladder augmentation is an acceptable option for decreasing detrusor pressure whenever less invasive procedures have failed. For the treatment of a severely thick or fibrotic bladder wall, a bladder substitution might be considered.	B
	Underactive	SARS with rhizotomy and sacral neuromodulation are effective in selected patients.	B
		Restoration of a functional bladder by covering with striated muscle is still experimental.	
Urethra	Overactive (DSD)	Prefer to guidelines for minimal invasive treatment (see Section 4.3.6).	
	Underactive	The placement of a urethral sling is an established procedure.	B
		The artificial urinary sphincter is very effective.	B
		Transposition of the gracilis muscle is still experimental.	

DSD = detrusor sphincter dyssynergia; SARS = sacral anterior root stimulation.

4.6 References

1. Stöhrer M, Kramer G, Löchner-Ernst D, et al. Diagnosis and treatment of bladder dysfunction in spinal cord injury patients. Eur Urol Update Series 1994;3:170-5.
2. Burns AS, Rivas DA, Ditunno JF. The management of neurogenic bladder and sexual dysfunction after spinal cord injury. Spine 2001 Dec;26 (24 Suppl):S129-136. http://www.ncbi.nlm.nih.gov/pubmed/11805620
3. Rickwood AM. Assessment and conservative management of the neuropathic bladder. Semin Pediatr Surg 2002 May;11(2):108-19. http://www.ncbi.nlm.nih.gov/pubmed/11973763

4. Castro-Diaz D, Barrett D, Grise P, et al. Surgery for the neuropathic patient. In: *Incontinence*, 2nd edn. Abrams P, Khoury S, Wein A, eds. Plymouth: Health Publication, 2002; pp. 865-891.
5. Donnelly J, Hackler RH, Bunts RC. Present urologic status of the World War II paraplegic: 25-year followup. Comparison with status of the 20-year Korean War paraplegic and 5-year Vietnam paraplegic. J Urol 1972 Oct;108(4):558-62. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/4651345
6. Hackler RH. A 25-year prospective mortality study in the spinal cord injured patient: comparison with the long-term living paraplegic. J Urol 1977 Apr;117(4):486-8.
http://www.ncbi.nlm.nih.gov/pubmed/850323
7. Game X, Castel-Lacanal E, Bentaleb Y, et al. Botulinum toxin A detrusor injections in patients with neurogenic detrusor overactivity significantly decrease the incidence of symptomatic urinary tract infections. Eur Urol 2008 Mar;53(3):613-8.
http://www.ncbi.nlm.nih.gov/pubmed/17804150
8. Frankel HL, Coll JR, Charlifue SW, et al. Long-term survival in spinal cord injury: a fifty year investigation. Spinal Cord 1998 Apr;36(4):266-74.
http://www.ncbi.nlm.nih.gov/pubmed/9589527
9. Stöhrer M. Alterations in the urinary tract after spinal cord injury-diagnosis, prevention and therapy of late sequelae. World J Urol 1990;7:205-11.
http://www.springerlink.com/content/k16411w744170641/
10. Barbalias GA, Klauber GT, Blaivas JG. Critical evaluation of the Credé maneuver: a urodynamic study of 207 patients. J Urol 1983 Oct;130(4):720-3.
http://www.ncbi.nlm.nih.gov/pubmed/6887405
11. Madersbacher H, Wyndaele JJ, Igawa Y, et al. Conservative management in neuropathic urinary incontinence. In: *Incontinence*, 2nd edn. Abrams P, Khoury S, Wein A, eds. Plymouth: Health Publication, 2002; pp. 697-754.
http://icsoffice.org/Publications/ICI_2/chapters/Chap10E.pdf
12. Van Kerrebroeck PE, Koldewijn EL, Scherpenhuizen S, et al. The morbidity due to lower urinary tract function in spinal cord injury patients. Paraplegia 1993 May;31(5):320-9.
http://www.ncbi.nlm.nih.gov/pubmed/8332378
13. Sekar P, Wallace DD, Waites KB, et al. Comparison of long-term renal function after spinal cord injury using different urinary management methods. Arch Phys Med Rehabil 1997 Sep;78(9):992-7.
http://www.ncbi.nlm.nih.gov/pubmed/9305274
14. Linsenmeyer TA, Bagaria SP, Gendron B. The impact of urodynamic parameters on the upper tracts of spinal cord injured men who void reflexly. J Spinal Cord Med 1998 Jan;21(1):15-20.
http://www.ncbi.nlm.nih.gov/pubmed/9541882
15. McKinley WO, Jackson AB, Cardenas DD, et al. Long-term medical complications after traumatic spinal cord injury: a regional model systems analysis. Arch Phys Med Rehabil 1999 Nov;80(11): 1402-10.
http://www.ncbi.nlm.nih.gov/pubmed/10569434
16. Weld KJ, Dmochowski RR. Effect of bladder management on urological complications in spinal cord injured patients. J Urol 2000 Mar;163(3):768-72.
http://www.ncbi.nlm.nih.gov/pubmed/10687973
17. Menon EB, Tan ES. Bladder training in patients with spinal cord injury. Urology 1992 Nov;40(5):425-9.
http://www.ncbi.nlm.nih.gov/pubmed/1441039
18. Nijman RJ. Classification and treatment of functional incontinence in children. BJU Int 2000 May;85(3): 37-42; discussion 45-6.
http://www.ncbi.nlm.nih.gov/pubmed/11954196
19. Aslan AR, Kogan BA. Conservative management in neurogenic bladder dysfunction. Curr Opin Urol 2002 Nov;12(6):473-7.
http://www.ncbi.nlm.nih.gov/pubmed/12409875
20. Christ KF, Kornhuber HH. Treatment of neurogenic bladder dysfunction in multiple sclerosis by ultrasound-controlled bladder training. Arch Psychiatr Nervenkr 1980;228(3):191-5.
http://www.ncbi.nlm.nih.gov/pubmed/7416934
21. De Ridder D, Vermeulen C, Ketelaer P, et al. Pelvic floor rehabilitation in multiple sclerosis. Acta Neurol Belg 1999 Mar;99(1):61-4.
http://www.ncbi.nlm.nih.gov/pubmed/10218095
22. Ishigooka M, Hashimoto T, Hayami S, et al. Electrical pelvic floor stimulation: a possible alternative treatment for reflex urinary incontinence in patients with spinal cord injury. Spinal Cord 1996 Jul;34(7): 411-5.
http://www.ncbi.nlm.nih.gov/pubmed/8963996

23. Balcom AH, Wiatrak M, Biefeld T, et al. Initial experience with home therapeutic electrical stimulation for continence in the myelomeningocele population. J Urol 1997 Sep;158(3 Pt 2):1272-6. http://www.ncbi.nlm.nih.gov/pubmed/9258193
24. Chin-Peuckert L, Salle JL. A modified biofeedback program for children with detrusor-sphincter dyssynergia: 5-year experience. J Urol 2001 Oct;166(4):1470-5. http://www.ncbi.nlm.nih.gov/pubmed/11547115
25. McClurg D, Ashe RG, Marshall K, et al. Comparison of pelvic floor muscle training, electromyography biofeedback, and neuromuscular electrical stimulation for bladder dysfunction in people with multiple sclerosis: a randomized pilot study. Neurourol Urodyn 2006;25(4):337-48. http://www.ncbi.nlm.nih.gov/pubmed/16637070
26. Fall M, Lindström S. Electrical stimulation. A physiologic approach to the treatment of urinary incontinence. Urol Clin North Am 1991 May;18(2):393-407. http://www.ncbi.nlm.nih.gov/pubmed/2017820
27. Vodusek DB, Light KJ, Libby JM. Detrusor inhibition induced by stimulation of pudendal nerve afferents. Neurourol Urodyn 1986;5:381-9.
28. Bemelmans BL, Mundy AR, Craggs MD. Neuromodulation by implant for treating lower urinary tract symptoms and dysfunction. Eur Urol 1999 Aug;36(2):81-91. http://www.ncbi.nlm.nih.gov/pubmed/10420026
29. Primus G, Kramer G. Maximal external electrical stimulation for treatment of neurogenic or non-neurogenic urgency and/or urge incontinence. Neurourol Urodyn 1996;15(3):187-94. http://www.ncbi.nlm.nih.gov/pubmed/8732985
30. Madersbacher H, Kiss G, Mair D. Transcutaneous electrostimulation of the pudendal nerve for treatment of detrusor overactivity. Neurourol Urodyn 1995;14:501-2.
31. Prévinaire JG, Soler JM, Perrigot M. Is there a place for pudendal nerve maximal electrical stimulation for the treatment of detrusor hyperreflexia in spinal cord injury patients? Spinal Cord 1998 Feb;36(2):100-3. http://www.ncbi.nlm.nih.gov/pubmed/9494999
32. Opisso E, Borau A, Rodríguez A, et al. Patient controlled versus automatic stimulation of pudendal nerve afferents to treat neurogenic detrusor overactivity. J Urol 2008 Oct;180(4):1403-8. http://www.ncbi.nlm.nih.gov/pubmed/18710774
33. Kabay S, Kabay SC, Yucel M, et al. The clinical and urodynamic results of a 3-month percutaneous posterior tibial nerve stimulation treatment in patients with multiple sclerosis-related neurogenic bladder dysfunction. Neurourol Urodyn 2009;28(8):964-8. http://www.ncbi.nlm.nih.gov/pubmed/19373898
34. Pannek J, Janek S, Noldus J. [Neurogenic or idiopathic destrusor overactivity after failed antimuscarinic treatment: clinical value of external temporary electrostimulation]. Urologe A 2010 Apr;49(4):530-5. [Article in German] http://www.ncbi.nlm.nih.gov/pubmed/20057991
35. McClurg D, Ashe RG, Lowe-Strong AS. Neuromuscular electrical stimulation and the treatment of lower urinary tract dysfunction in multiple sclerosis--a double blind, placebo controlled, randomised clinical trial. Neurourol Urodyn 2008;27(3):231-7. http://www.ncbi.nlm.nih.gov/pubmed/17705160
36. Hagerty JA, Richards I, Kaplan WE. Intravesical electrotherapy for neurogenic bladder dysfunction: a 22-year experience. J Urol 2007;178(4 Pt 2):1680-3. http://www.ncbi.nlm.nih.gov/pubmed/17707024
37. Primus G, Kramer G, Pummer K. Restoration of micturition in patients with acontractile and hypocontractile detrusor by transurethral electrical bladder stimulation. Neurourol Urodyn 1996;15(5): 489-97. http://www.ncbi.nlm.nih.gov/pubmed/8857617
38. Zempleni MZ, Michels L, Mehnert U, et al. Cortical substrate of bladder control in SCI and the effect of peripheral pudendal stimulation. Neuroimage 2010 Feb;49(4):2983-94. http://www.ncbi.nlm.nih.gov/pubmed/19878725
39. Brusa L, Petta F, Pisani A, et al. Central acute D2 stimulation worsens bladder function in patients with mild Parkinson's disease. J Urol 2006 Jan;175(1):202-6. http://www.ncbi.nlm.nih.gov/pubmed/16406911
40. Brusa L, Finazzi Agrò E, Petta F, et al. Effects of inhibitory rTMS on bladder function in Parkinson's disease patients. Mov Disord 2009 Feb;24(3):445-8. http://www.ncbi.nlm.nih.gov/pubmed/19133657

41. Baskin LS, Kogan BA, Benard F. Treatment of infants with neurogenic bladder dysfunction using anticholinergic drugs and intermittent catheterisation. Br J Urol 1990 Nov;66(5):532-4. http://www.ncbi.nlm.nih.gov/pubmed/2249125
42. Tanaka H, Kakizaki H, Kobayashi S, et al. The relevance of urethral resistance in children with myelodysplasia: its impact on upper urinary tract deterioration and the outcome of conservative management. J Urol 1999 Mar;161(3):929-32. http://www.ncbi.nlm.nih.gov/pubmed/10022727
43. Stone AR. Neurourologic evaluation and urologic management of spinal dysraphism. Neurosurg Clin N Am 1995 Apr;6(2):269-77. http://www.ncbi.nlm.nih.gov/pubmed/7620353
44. Edelstein RA, Bauer SB, Kelly MD, et al. The long-term urological response of neonates with myelodysplasia treated proactively with intermittent catheterization and anticholinergic therapy. J Urol 1995 Oct;154(4):1500-4. http://www.ncbi.nlm.nih.gov/pubmed/7658577
45. DasGupta R, Fowler CJ. Bladder, bowel and sexual dysfunction in multiple sclerosis: management strategies. Drugs 2003;63(2):153-66. http://www.ncbi.nlm.nih.gov/pubmed/12515563
46. Buyse G, Verpoorten C, Vereecken R, et al. Treatment of neurogenic bladder dysfunction in infants and children with neurospinal dysraphism with clean intermittent (self)catheterisation and optimized intravesical oxybutynin hydrochloride therapy. Eur J Pediatr Surg 1995 Dec;5 Suppl 1:31-4. http://www.ncbi.nlm.nih.gov/pubmed/8770576
47. Appell RA. Overactive bladder in special patient populations. Rev Urol 2003;5 Suppl 8:S37-41. http://www.ncbi.nlm.nih.gov/pubmed/16985989
48. Amend B, HennenlotterJ, Schäfer T, et al. Effective treatment of neurogenic detrusor dysfunction by combined high-dosed antimuscarinics without increased side-effects. Eur Urol 2008 May;53(5): 1021-8. http://www.ncbi.nlm.nih.gov/pubmed/18243516
49. Cameron AP, Clemens JQ, Latini JM, et al. Combination drug therapy improves compliance of the neurogenic bladder. J Urol 2009 Sep;182(3):1062-7. http://www.ncbi.nlm.nih.gov/pubmed/19616807
50. Alloussi SH, Mürtz G, Gitzhofer S, et al. Failure of monotherapy in primary monosymptomatic enuresis: a combined desmopressin and propiverine treatment regimen improves efficacy outcomes. BJU Int 2009 Jun;103(12):1706-12. http://www.ncbi.nlm.nih.gov/pubmed/19154456
51. Kennelly MJ, DeVoe WB. Overactive Bladder: Pharmacologic Treatments in the Neurogenic Population. Rev Urol 2008 Summer;10(3):182-91. http://www.ncbi.nlm.nih.gov/pubmed/18836537
52. Stöhrer M, Blok B, Castro-Diaz D, et al. EAU guidelines on neurogenic lower urinary tract dysfunction. Eur Urol 2009 Jul;56(1):81-8. http://www.ncbi.nlm.nih.gov/pubmed/19403235
53. Sakakibara R, Uchiyama T, Yamanishi T, et al. Dementia and lower urinary dysfunction: with a reference to anticholinergic use in elderly population Int J Urol 2008 Sep;15(9):778-88. http://www.ncbi.nlm.nih.gov/pubmed/18643858
54. Verpoorten C, Buyse GM. The neurogenic bladder: Medical treatment. Pediatr Nephrol 2008 May;23(5):717-25. http://www.ncbi.nlm.nih.gov/pubmed/18095004
55. Horstmann M, Schaefer T, Aguilar Y, et al. Neurogenic bladder treatment by doubling the recommended antimuscarinic dosage. Neurourol Urodyn 2006;25(5):441-5. http://www.ncbi.nlm.nih.gov/pubmed/16847942
56. Menarini M, Del Popolo G, Di Benedetto P, et al; TcP128-Study Group. Trospium chloride in patients with neurogenic detrusor overactivity: is dose titration of benefit to the patients? Int J Clin Pharmacol Ther 2006 Dec;44(12):623-32. http://www.ncbi.nlm.nih.gov/pubmed/17190372
57. O'Leary M, Erickson JR, Smith CP, et al. Effect of controlled release oxybutynin on neurogenic bladder function in spinal cord injury. J Spinal Cord Med 2003 Summer;26(2):159-62. http://www.ncbi.nlm.nih.gov/pubmed/12828295
58. Stöhrer M, Mürtz G, Kramer G, et al; Propiverine Investigator Group. Propiverine compared to oxybutynin in neurogenic detrusor overactivity--results of a randomized, double-blind, multicenter clinical study. Eur Urol 2007 Jan;51(1):235-42. http://www.ncbi.nlm.nih.gov/pubmed/16698176

59. Schwantes U, Topfmeier P. Importance of pharmacological and physicochemical properties for tolerance of antimuscarinic drugs in the treatment of detrusor instability and detrusor hyperreflexia --chances for improvement of therapy. Int J Clin Pharmacol Ther 1999 May;37(5):209-18. http://www.ncbi.nlm.nih.gov/pubmed/10363619
60. Isik AT, Celik T, Bozoglu E, et al. Trospium and cognition in patients with late onset Alzheimer disease. J Nutr Health Aging 2009 Oct;13(8):672-6. http://www.ncbi.nlm.nih.gov/pubmed/19657549
61. Ethans KD, Nance PW, Bard RJ, et al. Efficacy and safety of tolterodine in people with neurogenic detrusor overactivity. J Spinal Cord Med 2004;27(3):214-8. http://www.ncbi.nlm.nih.gov/pubmed/15478523
62. Reddy PP, Borgstein NG, Nijman RJ, et al. Long-term efficacy and safety of tolterodine in children with neurogenic detrusor overactivity. J Pediatr Urol 2008 Dec;4(6):428-33. http://www.ncbi.nlm.nih.gov/pubmed/19013412
63. Mahanta K, Medhi B, Kaur B, et al. Comparative efficacy and safety of extended-release and instant-release tolterodine in children with neural tube defects having cystometric abnormalities. J Pediatr Urol 2008 Apr;4(2)118-23. http://www.ncbi.nlm.nih.gov/pubmed/18631906
64. Grigoleit U, Mürtz G, Laschke S, et al. Efficacy, tolerability and safety of propiverine hydrochloride in children and adolescents with congenital or traumatic neurogenic detrusor overactivity: a retrospective study. Eur Urol 2006 Jun;49(6):1114-21; discussion 1120-1. http://www.ncbi.nlm.nih.gov/pubmed/16542772
65. Madersbacher H, Mürtz G, Alloussi S, et al. Propiverine vs oxybutynin for treating neurogenic detrusor overactivity in children and adolescents: results of a multicentre observational cohort study. BJU Int 2009 Mar;103(6):776-81. http://www.ncbi.nlm.nih.gov/pubmed/19007380
66. Menarini M, Del Popolo G, Di Benedetto P, et al; TcP128-Study Group. Int J Clin Pharmacol Ther 2006 Dec;44(12):623-32
67. Carl S, Laschke S. Darifenacin is also effective in neurogenic bladder dysfunction (multiple sclerosis). Urology 2006;68(suppl):250.
68. Bycroft J, Leaker B, Wood S, et al. The effect of darifenacin on neurogenic detrusor overactivity in patients with spinal cord injury. Neurourol Urodyn 2003;22:A190.
69. Cartwright PC, Coplen DE, Kogan BA, et al. Efficacy and safety of transdermal and oral oxybutynin in children with neurogenic detrusor overactivity. J Urol 2009 Oct;182(4):1548-54. http://www.ncbi.nlm.nih.gov/pubmed/19683731
70. Kennelly MJ, Lemack GE, Foote JE, et al. Efficacy and safety of oxybutynin transdermal system in spinal cord injury patients with neurogenic detrusor overactivity and incontinence: an open-label, dose-titration study. Urology 2009 Oct;74(4):741-5. http://www.ncbi.nlm.nih.gov/pubmed/19628264
71. Van Meel TD, De Wachter S, Wyndaele JJ. The effect of intravesical oxybutynin on the ice water test and on electrical perception thresholds in patients with neurogenic detrusor overactivity. Neurourol Urodyn 2010 Mar;29(3):391-4. http://www.ncbi.nlm.nih.gov/pubmed/19787712
72. Gacci M, Del Popolo G, Macchiarella A, et al. Vardenafil improves urodynamic parameters in men with spinal cord injury: results from a single dose, pilot study. J Urol 2007 Nov;178(5):2040-3; discussion 2044. http://www.ncbi.nlm.nih.gov/pubmed/17869296
73. Chancellor MB, Rivas DA, Staas WE Jr. DDAVP in the urological management of the difficult neurogenic bladder in spinal cord injury: preliminary report. J Am Paraplegia Soc 1994 Oct;17(4): 165-7. http://www.ncbi.nlm.nih.gov/pubmed/7869058
74. Valiquette G, Herbert J, Maede-D'Alisera P. Desmopressin in the management of nocturia in patients with multiple sclerosis. A double-blind, crossover trial. Arch Neurol 1996 Dec;53(12):1270-5. http://www.ncbi.nlm.nih.gov/pubmed/8970454
75. Panicker JN, de Sèze M, Fowler CJ. Rehabilitation in practice: neurogenic lower urinary tract dysfunction and its management. Clin Rehabil 2010 Jul;24(7):579-89. http://www.ncbi.nlm.nih.gov/pubmed/20584864
76. Barendrecht MM, Oelke M, Laguna MP, et al. Is the use of parasympathomimetics for treating an underactive urinary bladder evidence-based? BJU Int 2007 Apr;99(4):749-52. http://www.ncbi.nlm.nih.gov/pubmed/17233798

77. Yamanishi T, Yasuda K, Kamai T, et al. Combination of a cholinergic drug and an alpha-blocker is more effective than monotherapy for the treatment of voiding difficulty in patients with underactive detrusor. Int J Urol 2004 Feb;11(2):88-96.
http://www.ncbi.nlm.nih.gov/pubmed/14706012
78. Wheeler JS Jr, Robinson CJ, Culkin DJ, et al. Naloxone efficacy in bladder rehabilitation of spinal cord injury patients. J Urol 1987 Jun;137(6):1202-5.
http://www.ncbi.nlm.nih.gov/pubmed/3586156
79. Komersova K, Rogerson JW, Conway EL, et al. The effect of levcromakalim (BRL 38227) on bladder function in patients with high spinal cord lesions. Br J Clin Pharmacol 1995 Feb;39(2):207-9.
http://www.ncbi.nlm.nih.gov/pubmed/7742166
80. Wyndaele JJ, van Kerrebroeck P. The effects of 4 weeks treatment with cisapride on cystometric parameters in spinal cord injury patients. A double-blind, placebo controlled study. Paraplegia 1995 Nov;33(11):625-7.
http://www.ncbi.nlm.nih.gov/pubmed/8584295
81. Costa P, Bressolle F, Sarrazin B, et al. Dose-related effect of moxisylyte on maximal urethral closing pressure in patients with spinal cord injuries. Clin Pharmacol Ther 1993 Apr;53(4);443-9.
http://www.ncbi.nlm.nih.gov/pubmed/8477560
82. Cain MP, Wu SD, Austin PF, et al. Alpha blocker therapy for children with dysfunctional voiding and urinary retention. J Urol 2003 Oct;170(4 Pt 2):1514-5 discussion 1516-7.
http://www.ncbi.nlm.nih.gov/pubmed/14501648
83. Schulte-Baukloh H, Michael T, Miller K, et al. Alfuzosin in the treatment of high leak-point pressure in children with neurogenic bladder. BJU Int 2002 Nov;90(7):716-20.
http://www.ncbi.nlm.nih.gov/pubmed/12410754
84. Abrams P, Amarenco G, Bakke A, et al; European Tamsulosin Neurogenic Lower Urinary Tract Dysfunction Study Group. Tamsulosin: efficacy and safety in patients with neurogenic lower urinary tract dysfunction due to suprasacral spinal cord injury. J Urol 2003 Oct;170(4 Pt 1):1242-51.
http://www.ncbi.nlm.nih.gov/pubmed/14501734
85. Yasuda K, Yamanishi T, Kawabe K, et al. The effect of urapidil on neurogenic bladder: a placebo controlled double-blind study. J Urol 1996 Sep;156(3):1125-30.
http://www.ncbi.nlm.nih.gov/pubmed/8709324
86. Al-Ali M, Salman G, Rasheed A, et al. Phenoxybenzamine in the management of neuropathic bladder following spinal cord injury. Aust N Z J Surg 1999 Sep;69(9):660-3.
http://www.ncbi.nlm.nih.gov/pubmed/10515340
87. Te AE. A modern rationale for the use of phenoxybenzamine in urinary tract disorders and other conditions. Clin Ther 2002 Jun;24(6):851-61; discussion 837.
http://www.ncbi.nlm.nih.gov/pubmed/12117078
88. Guttmann L, Frankel H. The value of intermittent catheterisation in the early management of traumatic paraplegia and tetraplegia. Paraplegia 1966 Aug;4(2):63-84.
http://www.ncbi.nlm.nih.gov/pubmed/5969402
89. Lapides J, Diokno AC, Silber SJ, et al. Clean, intermittent self-catheterization in the treatment of urinary tract disease. J Urol 1972 Mar;107(3):458-61. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/5010715
90. Baskin LS, Kogan BA, Benard F. Treatment of infants with neurogenic bladder dysfunction using anticholinergic drugs and intermittent catheterisation. Br J Urol 1990 Nov;66(5):532-4.
http://www.ncbi.nlm.nih.gov/pubmed/2249125
91. Tanaka H, Kakizaki H, Kobayashi S, et al. The relevance of urethral resistance in children with myelodysplasia: its impact on upper urinary tract deterioration and the outcome of conservative management. J Urol 1999 Mar;161(3):929-32.
http://www.ncbi.nlm.nih.gov/pubmed/10022727
92. Stone AR. Neurourologic evaluation and urologic management of spinal dysraphism. Neurosurg Clin N Am 1995 Apr;6(2):269-77.
http://www.ncbi.nlm.nih.gov/pubmed/7620353
93. Edelstein RA, Bauer SB, Kelly MD, et al. The long-term urological response of neonates with myelodysplasia treated proactively with intermittent catheterization and anticholinergic therapy. J Urol 1995 Oct;154(4):1500-4.
http://www.ncbi.nlm.nih.gov/pubmed/7658577
94. DasGupta R, Fowler CJ. Bladder, bowel and sexual dysfunction in multiple sclerosis: management strategies. Drugs 2003;63(2):153-66.
http://www.ncbi.nlm.nih.gov/pubmed/12515563

95. Buyse G, Verpoorten C, Vereecken R, et al. Treatment of neurogenic bladder dysfunction in infants and children with neurospinal dysraphism with clean intermittent (self)catheterisation and optimized intravesical oxybutynin hydrochloride therapy. Eur J Pediatr Surg 1995 Dec;5 Suppl 1:31-4. http://www.ncbi.nlm.nih.gov/pubmed/8770576
96. Wyndaele JJ. Intermittent catheterization: which is the optimal technique? Spinal Cord 2002 Sep;40(9):432-7. http://www.ncbi.nlm.nih.gov/pubmed/12185603
97. Prieto-Fingerhut T, Banovac K, Lynne CM. A study comparing sterile and nonsterile urethral catheterization in patients with spinal cord injury. Rehabil Nurs 1997 Nov-Dec;22(6):299-302. http://www.ncbi.nlm.nih.gov/pubmed/9416190
98. Matsumoto T, Takahashi K, Manabe N, et al. Urinary tract infection in neurogenic bladder. Int J Antimicrob Agents 2001 Apr;17(4):293-7. http://www.ncbi.nlm.nih.gov/pubmed/11295411
99. Hudson E, Murahata RI. The 'no-touch' method of intermittent urinary catheter insertion: can it reduce the risk of bacteria entering the bladder? Spinal Cord 2005 Oct;43(10):611-4. http://www.ncbi.nlm.nih.gov/pubmed/15852058
100. Waller L, Jonsson O, Norlén L, et al. Clean intermittent catheterization in spinal cord injury patients: long-term follow-up of a hydrophilic low friction technique. J Urol 1995 Feb;153(2):345-8. http://www.ncbi.nlm.nih.gov/pubmed/7815579
101. Bakke A, Digranes A, Høisaeter PA. Physical predictors of infection in patients treated with clean intermittent catheterization: a prospective 7-year study. Br J Urol 1997 Jan;79(1):85-90. http://www.ncbi.nlm.nih.gov/pubmed/9043503
102. Gunther M, Lochner-Ernst D, Kramer G, et al. [Effects of aseptic intermittent catheterisation on the male urethra] Urologe B 2001;41:359-361. [Article in German] http://www.springerlink.com/content/9cevbv7hayf09xta/
103. Wyndaele JJ. Complications of intermittent catheterization: their prevention and treatment. Spinal Cord 2002 Oct;40(10):536-41. http://www.ncbi.nlm.nih.gov/pubmed/12235537
104. Sauerwein D. Urinary tract infection in patients with neurogenic bladder dysfunction. Int J Antimicrob Agents 2002 Jun;19(6):592-7. http://www.ncbi.nlm.nih.gov/pubmed/12135853
105. Sullivan LP, Davidson PG, Kloss DA, et al. Small-bowel obstruction caused by a long-term indwelling urinary catheter. Surgery 1990 Feb;107(2):228-30. http://www.ncbi.nlm.nih.gov/pubmed/2300902
106. Chao R, Clowers D, Mayo ME. Fate of upper urinary tracts in patients with indwelling catheters after spinal cord injury. Urology 1993 Sep;42(3):259-62. http://www.ncbi.nlm.nih.gov/pubmed/8379025
107. Chancellor MB, Erhard MJ, Kiilholma PJ, et al. Functional urethral closure with pubovaginal sling for destroyed female urethra after long-term urethral catheterization. Urology 1994 Apr;43(4):499-505. http://www.ncbi.nlm.nih.gov/pubmed/8154071
108. Bennett CJ, Young MN, Adkins RH, et al. Comparison of bladder management complication outcomes in female spinal cord injury patients. J Urol 1995 May;153(5):1458-60. http://www.ncbi.nlm.nih.gov/pubmed/7714965
109. Larsen LD, Chamberlin DA, Khonsari F, et al. Retrospective analysis of urologic complications in male patients with spinal cord injury managed with and without indwelling urinary catheters. Urology 1997 Sep;50(3):418-22. http://www.ncbi.nlm.nih.gov/pubmed/9301708
110. West DA, Cummings JM, Longo WE, et al. Role of chronic catheterization in the development of bladder cancer in patients with spinal cord injury. Urology 1999 Feb;53(2):292-7. http://www.ncbi.nlm.nih.gov/pubmed/9933042
111. Mitsui T, Minami K, Furuno T, et al. Is suprapubic cystostomy an optimal urinary management in high quadriplegics? A comparative study of suprapubic cystostomy and clean intermittent catheterization. Eur Urol 2000 Oct;38(4):434-8. http://www.ncbi.nlm.nih.gov/pubmed/11025382
112. Weld KJ, Wall BM, Mangold TA, et al, Dmochowski RR. Influences on renal function in chronic spinal cord injured patients. J Urol 2000 Nov;164(5):1490-3. http://www.ncbi.nlm.nih.gov/pubmed/11025689
113. Zermann D, Wunderlich H, Derry F, et al. Audit of early bladder management complications after spinal cord injury in first-treating hospitals. Eur Urol 2000 Feb;37(2):156-60. http://www.ncbi.nlm.nih.gov/pubmed/10705193

114. Park YI, Linsenmeyer TA. A method to minimize indwelling catheter calcification and bladder stones in individuals with spinal cord injury. J Spinal Cord Med 2001 Summer;24(2):105-8.
http://www.ncbi.nlm.nih.gov/pubmed/11587416
115. Glickman S, Tsokkos N, Shah PJ. Intravesical atropine and suppression of detrusor hypercontractility in the neuropathic bladder. A preliminary study. Paraplegia 1995 Jan;33(1):36-9.
http://www.ncbi.nlm.nih.gov/pubmed/7715952
116. Amark P, Bussman G, Eksborg S. Follow-up of long-time treatment with intravesical oxybutynin for neurogenic bladder in children. Eur Urol 1998 Aug;34(2):148-53.
http://www.ncbi.nlm.nih.gov/pubmed/9693251
117. Haferkamp A, Staehler G, Gerner HJ, et al. Dosage escalation of intravesical oxybutynin in the treatment of neurogenic bladder patients. Spinal Cord 2000 Apr;38(4):250-4.
http://www.ncbi.nlm.nih.gov/pubmed/10822396
118. Pannek J, Sommerfeld HJ, Bötel U, et al. Combined intravesical and oral oxybutynin chloride in adult patients with spinal cord injury. Urology 2000 Mar;55(3):358-62.
http://www.ncbi.nlm.nih.gov/pubmed/10699610
119. Buyse G, Waldeck K, Verpoorten C, et al. Intravesical oxybutynin for neurogenic bladder dysfunction: less systemic side effects due to reduced first pass metabolism. J Urol 1998 Sep;160(3 Pt 1):892-6.
http://www.ncbi.nlm.nih.gov/pubmed/9720583
120. Riedl CR, Knoll M, Plas E, et al. Intravesical electromotive drug administration technique: preliminary results and side effects. J Urol 1998 Jun;159(6):1851-6.
http://www.ncbi.nlm.nih.gov/pubmed/9598474
121. Di Stasi SM, Giannantoni A, Navarra P, et al. Intravesical oxybutynin: mode of action assessed by passive diffusion and electromotive administration with pharmacokinetics of oxybutynin and N-desethyl oxybutynin. J Urol 2001 Dec;166(6):2232-6.
http://www.ncbi.nlm.nih.gov/pubmed/11696741
122. Geirsson G, Fall M, Sullivan L. Clinical and urodynamic effects of intravesical capsaicin treatment in patients with chronic traumatic spinal detrusor hyperreflexia. J Urol 1995 Nov;154(5):1825-9.
http://www.ncbi.nlm.nih.gov/pubmed/7563356
123. Cruz F, Guimarães M, Silva C, et al. Suppression of bladder hyperreflexia by intravesical resiniferatoxin. Lancet 1997 Aug;350(9078):640-1.
http://www.ncbi.nlm.nih.gov/pubmed/9288055
124. De Ridder D, Chandiramani V, Dasgupta P, et al. Intravesical capsaicin as a treatment for refractory detrusor hyperreflexia: a dual center study with long-term followup. J Urol 1997 Dec;158(6):2087-92.
http://www.ncbi.nlm.nih.gov/pubmed/9366318
125. Wiart L, Joseph PA, Petit H, et al. The effects of capsaicin on the neurogenic hyperreflexic detrusor. A double blind placebo controlled study in patients with spinal cord disease. Preliminary results. Spinal Cord 1998 Feb;36(2):95-9.
http://www.ncbi.nlm.nih.gov/pubmed/9494998
126. Kim JH, Rivas DA, Shenot PJ, et al. Intravesical resiniferatoxin for refractory detrusor hyperreflexia: a multicenter, blinded, randomized, placebo-controlled trial. J Spinal Cord Med 2003 Winter;26(4): 358-63.
http://www.ncbi.nlm.nih.gov/pubmed/14992337
127. Giannantoni A, Di Stasi SM, Stephen RL, et al. Intravesical resiniferatoxin versus botulinum-A toxin injections for neurogenic detrusor overactivity: a prospective randomized study. J Urol 2004 Jul;172(1):240-3.
http://www.ncbi.nlm.nih.gov/pubmed/15201783
128. Katona F, Benyo L, Lang I. [Intraluminary electrotherapy of various paralytic conditions of the gastrointestinal tract with the quadrangular current.] Zentralbl Chir 1959 Jun;84(24):929-33. [Article in German] [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/13676705
129. Kaplan WE. Intravesical electrical stimulation of the bladder: pro. Urology 2000 Jul;56(1):2-4.
http://www.ncbi.nlm.nih.gov/pubmed/10869607
130. Ebner A, Jiang C, Lindström S. Intravesical electrical stimulation-an experimental analysis of the mechanism of action. J Urol 1992 Sep;148(3):920-4.
http://www.ncbi.nlm.nih.gov/pubmed/1512860
131. Primus G, Kramer G, Pummer K. Restoration of micturition in patients with acontractile and hypocontractile detrusor by transurethral electrical bladder stimulation. Neurourol Urodyn 1996;15(5): 489-97.
http://www.ncbi.nlm.nih.gov/pubmed/8857617

132. De Wachter S, Wyndaele JJ. Quest for standardisation of electrical sensory testing in the lower urinary tract: the influence of technique related factors on bladder electrical thresholds. Neurourol Urodyn 2003;22(2):118-22.
http://www.ncbi.nlm.nih.gov/pubmed/12579628
133. Katona F, Berenyi M. Intravesical transurethral electrotherapy in meningomyelocele patients. Acta Paediatr Acad Sci Hung 1975;16(3-4):363-74.
http://www.ncbi.nlm.nih.gov/pubmed/773096
134. Hagerty JA, Richards I, Kaplan WE. Intravesical electrotherapy for neurogenic bladder dysfunction: a 22-year experience. J Urol 2007 Oct;178(4 Pt 2):1680-3;discussion 1683.
http://www.ncbi.nlm.nih.gov/pubmed/17707024
135. Nicholas JL, Eckstein HB. Endovesical electrotherapy in treatment of urinary incontinence in spina-bifida patients. Lancet 1975 Dec;2(7948):1276-7.
http://www.ncbi.nlm.nih.gov/pubmed/54798
136. Pugach JL, Salvin L, Steinhardt GF. Intravesical electrostimulation in pediatric patients with spinal cord defects. J Urol 2000 Sep;164(3 Pt 2):965-8.
http://www.ncbi.nlm.nih.gov/pubmed/10958718
137. Stöhrer M, Schurch B, Kramer G, et al. Botulinum-A toxin in the treatment of detrusor hyperreflexia in spinal cord injury: a new alternative to medical and surgical procedures? Neurourol Urodyn 1999;18:401-2.
138. Schurch B, Schmid DM, Stöhrer M. Treatment of neurogenic incontinence with botulinum toxin A (letter). N Engl J Med 2000 Mar;342(9):665.
http://www.ncbi.nlm.nih.gov/pubmed/10702067
139. Schurch B, Stöhrer M, Kramer G, et al. Botulinum-A toxin for treating detrusor hyperreflexia in spinal cord injured patients: a new alternative to anticholinergic drugs? Preliminary results. J Urol 2000 Sep;164(3 Pt 1):692-7.
http://www.ncbi.nlm.nih.gov/pubmed/10953127
140. Schulte-Baukloh H, Michael T, Schobert J, et al. Efficacy of botulinum-A toxin in children with detrusor hyperreflexia due to myelomeningocele: preliminary results. Urology 2002 Mar;59(3):325-7; discussion 327-8.
http://www.ncbi.nlm.nih.gov/pubmed/11880062
141. Wyndaele JJ, Van Dromme SA. Muscular weakness as side effect of botulinum toxin injection for neurogenic detrusor overactivity. Spinal Cord 2002 Nov;40(11):599-600.
http://www.ncbi.nlm.nih.gov/pubmed/12411968
142. 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(4):510-15.
http://www.ncbi.nlm.nih.gov/pubmed/15041117
143. Del Popolo G, Filocamo MT, Li Marzi V, et al. Neurogenic detrusor overactivity treated with English Botulinum Toxin A: 8-year experience of one single centre. Eur Urol 2008 May;53(5):1013-19.
http://www.ncbi.nlm.nih.gov/pubmed/17950989
144. Schurch B, de Sèze M, Denys P, et al; Botox Detrusor Hyperreflexia Study Team. 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 Jul;174(1):196-200.
http://www.ncbi.nlm.nih.gov/pubmed/15947626
145. Akbar M, Abel R, Seyler TM, et al. Repeated botulinum-A toxin injections in the treatment of myelodysplastic children and patients with spinal cord injuries with neurogenic bladder dysfunction. BJU Int 2007 Sep;100(3):639-45.
http://www.ncbi.nlm.nih.gov/pubmed/17532858
146. Grosse J, Kramer G, Stöhrer M. Success of repeat detrusor injections of botulinum a toxin in patients with severe neurogenic detrusor overactivity and incontinence. Eur Urol 2005 May;47(5):653-9.
http://www.ncbi.nlm.nih.gov/pubmed/15826758
147. Haferkamp A, Schurch B, Reitz A, et al. Lack of ultrastructural detrusor changes following endoscopic injection of botulinum toxin type a in overactive neurogenic bladder. Eur Urol 2004 Dec;46(6):784-91.
http://www.ncbi.nlm.nih.gov/pubmed/15548448
148. Dykstra DD, Sidi AA. Treatment of detrusor-sphincter dyssynergia with botulinum A toxin: a double-blind study. Arch Phys Med Rehabil 1990 Jan;71(1):24-6.
http://www.ncbi.nlm.nih.gov/pubmed/2297305
149. Schurch B, Hauri D, Rodic B, et al. Botulinum-A toxin as a treatment of detrusor-sphincter dyssynergia: a prospective study in 24 spinal cord injury patients. J Urol 1996 Mar;155(3):1023-9.
http://www.ncbi.nlm.nih.gov/pubmed/8583552

150. Petit H, Wiart L, Gaujard E, et al. Botulinum A toxin treatment for detrusor-sphincter dyssynergia in spinal cord disease. Spinal Cord 1998 Feb;36(2):91-4.
http://www.ncbi.nlm.nih.gov/pubmed/9494997
151. Chancellor MB, Rivas DA, Abdill CK, et al. Prospective comparison of external sphincter balloon dilatation and prosthesis placement with external sphincterotomy in spinal cord injured men. Arch Phys Med Rehabil 1994 Mar;75(3):297-305.
http://www.ncbi.nlm.nih.gov/pubmed/8129583
152. Perkash I. Use of contact laser crystal tip firing Nd:YAG to relieve urinary outflow obstruction in male neurogenic bladder patients. J Clin Laser Med Surg 1998 Feb;16(1):33-8.
http://www.ncbi.nlm.nih.gov/pubmed/9728128
153. Noll F, Sauerwein D, Stöhrer M. Transurethral sphincterotomy in quadriplegic patients: long-term-follow-up. Neurourol Urodyn 1995;14(4):351-8.
http://www.ncbi.nlm.nih.gov/pubmed/7581471
154. Reynard JM, Vass J, Sullivan ME, et al. Sphincterotomy and the treatment of detrusor-sphincter dyssynergia: current status, future prospects. Spinal Cord 2003 Jan;41(1):1-11.
http://www.ncbi.nlm.nih.gov/pubmed/12494314
155. Derry F, al-Rubeyi S. Audit of bladder neck resection in spinal cord injured patients. Spinal Cord 1998 May;36(5):345-8.
http://www.ncbi.nlm.nih.gov/pubmed/9601115
156. Chancellor MB, Gajewski J, Ackman CF, et al. Long-term followup of the North American multicenter UroLume trial for the treatment of external detrusor-sphincter dyssynergia. J Urol 1999 May;161(5):1545-50.
http://www.ncbi.nlm.nih.gov/pubmed/10210393
157. Seoane-Rodríguez S, Sánchez R-Losada J, Montoto-Marqués A, et al. Long-term follow-up study of intraurethral stents in spinal cord injured patients with detrusor-sphincter dyssynergia. Spinal Cord 2007 Sep;45(9):621-6.
http://www.ncbi.nlm.nih.gov/pubmed/17211463
158. Gajewski JB, Chancellor MB, Ackman CF, et al. Removal of UroLume endoprosthesis: experience of the North American Study Group for detrusor-sphincter dyssynergia application. J Urol 2000 Mar;163(3):773-6.
http://www.ncbi.nlm.nih.gov/pubmed/10687974
159. Wilson TS, Lemack GE, Dmochowski RR. UroLume stents: lessons learned. J Urol 2002 Jun;167(6):2477-80.
http://www.ncbi.nlm.nih.gov/pubmed/11992061
160. Bennett JK, Green BG, Foote JE, et al. Collagen injections for intrinsic sphincter deficiency in the neuropathic urethra. Paraplegia 1995 Dec;33(12):697-700.
http://www.ncbi.nlm.nih.gov/pubmed/8927407
161. Guys JM, Simeoni-Alias J, Fakhro A, et al. Use of polydimethylsiloxane for endoscopic treatment of neurogenic urinary incontinence in children. J Urol 1999 Dec;162(6):2133-5.
http://www.ncbi.nlm.nih.gov/pubmed/10569603
162. Kassouf W, Capolicchio G, Berardinucci G, et al. Collagen injection for treatment of urinary incontinence in children. J Urol 2001 May;165(5):1666-8.
http://www.ncbi.nlm.nih.gov/pubmed/11342951
163. Caione P, Capozza N. Endoscopic treatment of urinary incontinence in pediatric patients: 2-year experience with dextranomer/hyaluronic acid copolymer. J Urol 2002 Oct;168(4 Pt 2):1868-71.
http://www.ncbi.nlm.nih.gov/pubmed/12352378
164. Block CA, Cooper CS, Hawtrey CE. Long-term efficacy of periurethral collagen injection for the treatment of urinary incontinence secondary to myelomeningocele. J Urol 2003 Jan;169(1):327-9.
http://www.ncbi.nlm.nih.gov/pubmed/12478183
165. Schurch B, Suter S, Dubs M. Intraurethral sphincter prosthesis to treat hyporeflexic bladders in women: does it work? BJU Int 1999 Nov;84(7):789-94.
http://www.ncbi.nlm.nih.gov/pubmed/10532973
166. Herschorn S, Radomski SB. Fascial slings and bladder neck tapering in the treatment of male neurogenic incontinence. J Urol 1992 Apr;147(4):1073-5.
http://www.ncbi.nlm.nih.gov/pubmed/1552586
167. Gormley EA, Bloom DA, McGuire EJ, et al. Pubovaginal slings for the management of urinary incontinence in female adolescents. J Urol 1994 Aug;152(2 Pt 2):822-5; discussion 826-7.
http://www.ncbi.nlm.nih.gov/pubmed/8022024

168. Kakizaki H, Shibata T, Shinno Y, et al. Fascial sling for the management of urinary incontinence due to sphincter incompetence. J Urol 1995 Mar;153(3 Pt 1):644-7.
http://www.ncbi.nlm.nih.gov/pubmed/7861504
169. Gosalbez R, Castellan M. Defining the role of the bladder-neck sling in the surgical treatment of urinary incontinence in children with neurogenic incontinence. World J Urol 1998;16(4):285-91.
http://www.ncbi.nlm.nih.gov/pubmed/9775429
170. Barthold JS, Rodriguez E, Freedman AL, et al. Results of the rectus fascial sling and wrap procedures for the treatment of neurogenic sphincteric incontinence. J Urol 1999 Jan;161(1):272-4.
http://www.ncbi.nlm.nih.gov/pubmed/10037423
171. Dik P, Van Gool JD, De Jong TP. Urinary continence and erectile function after bladder neck sling suspension in male patients with spinal dysraphism. BJU Int 1999 Jun;83(9):971-5.
http://www.ncbi.nlm.nih.gov/pubmed/10368238
172. Kryger JV, Gonzalez R, Barthold JS. Surgical management of urinary incontinence in children with neurogenic sphincteric incompetence. J Urol 2000 Jan;163(1):256-63.
http://www.ncbi.nlm.nih.gov/pubmed/10604371
173. Walker RD, Erhard M, Starling J. Long-term evaluation of rectus fascial wrap in patients with spina bifida. J Urol 2000 Aug;164(2):485-6.
http://www.ncbi.nlm.nih.gov/pubmed/10893629
174. Kapoor R, Dubey D, Kumar A, et al. Modified bulbar urethral sling procedure for the treatment of male sphincteric incontinence. J Endourol 2001 Jun;15(5):545-9.
http://www.ncbi.nlm.nih.gov/pubmed/11465337
175. Nguyen HT, Bauer SB, Diamond DA, et al. Rectus fascial sling for the treatment of neurogenic sphincteric incontinence in boys: is it safe and effective? J Urol 2001 Aug;166(2):658-61.
http://www.ncbi.nlm.nih.gov/pubmed/11458113
176. Austin PF, Westney OL, Leng WW, et al. Advantages of rectus fascial slings for urinary incontinence in children with neuropathic bladders. J Urol 2001 Jun;165(6 Pt 2):2369-71;discussion 2371-2.
http://www.ncbi.nlm.nih.gov/pubmed/11398778
177. Mingin GC, Youngren K, Stock JA, et al. The rectus myofascial wrap in the management of urethral sphincter incompetence. BJU Int 2002 Oct;90(6):550-3.
http://www.ncbi.nlm.nih.gov/pubmed/12230615
178. Colvert JR 3rd, Kropp BP, Cheng EY, et al. The use of small intestinal submucosa as an off-the-shelf urethral sling material for pediatric urinary incontinence. J Urol 2002 Oct;168(4 Pt 2):1872-5; discussion 1875-6.
http://www.ncbi.nlm.nih.gov/pubmed/12352379
179. Daneshmand S, Ginsberg DA, Bennet JK, et al. Puboprostatic sling repair for treatment of urethral incompetence in adult neurogenic incontinence. J Urol 2003 Jan;169(1):199-202.
http://www.ncbi.nlm.nih.gov/pubmed/12478135
180. Light JK, Scott FB. Use of the artificial urinary sphincter in spinal cord injury patients. J Urol 1983 Dec;130(6):1127-9.
http://www.ncbi.nlm.nih.gov/pubmed/6644893
181. Sidi AA, Reinberg Y, Gonzalez R. Comparison of artificial sphincter implantation and bladder neck reconstruction in patients with neurogenic urinary incontinence. J Urol 1987 Oct;138(4 Pt 2):1120-2.
http://www.ncbi.nlm.nih.gov/pubmed/3656572
182. Fulford SC, Sutton C, Bales G, et al. The fate of the 'modern' artificial urinary sphincter with a follow-up of more than 10 years. Br J Urol 1997 May;79(5):713-6.
http://www.ncbi.nlm.nih.gov/pubmed/9158507
183. Elliott DS, Barrett DM. Mayo Clinic long-term analysis of the functional durability of the AMS 800 artificial urinary sphincter: a review of 323 cases. J Urol 1998 Apr;159(4):1206-8.
http://www.ncbi.nlm.nih.gov/pubmed/9507835
184. Castera R, Podésta ML, Ruarte A, et al. 10-Year experience with artificial urinary sphincter in children and adolescents. J Urol 2001 Jun;165(6 Pt 2):2373-6.
http://www.ncbi.nlm.nih.gov/pubmed/11371980
185. Kryger JV, Leverson G, González R. Long-term results of artificial urinary sphincters in children are independent of age at implantation. J Urol 2001 Jun;165(6 Pt 2):2377-9.
http://www.ncbi.nlm.nih.gov/pubmed/11371981
186. Janknegt RA, Baeten CG, Weil EH, et al. Electrically stimulated gracilis sphincter for treatment of bladder sphincter incontinence. Lancet 1992 Nov;340(8828):1129-30.
http://www.ncbi.nlm.nih.gov/pubmed/1359213

187. Chancellor MB, Heesakkers JP, Janknegt RA. Gracilis muscle transposition with electrical Stimulation for sphincteric incontinence: a new approach. World J Urol 1997;15(5):320-8. http://www.ncbi.nlm.nih.gov/pubmed/9372585
188. Donnahoo KK, Rink RC, Cain MP, et al. The Young-Dees-Leadbetter bladder neck repair for neurogenic incontinence. J Urol 1999 Jun;161(6):1946-9. http://www.ncbi.nlm.nih.gov/pubmed/10332478
189. Kropp KA, Angwafo FF. Urethral lengthening and reimplantation for neurogenic incontinence in children. J Urol 1986 Mar;135(3):533-6. http://www.ncbi.nlm.nih.gov/pubmed/3944902
190. Salle JL, McLorie GA, Bägli DJ, et al. Urethral lengthening with anterior bladder wall flap (Pippi Salle procedure): modifications and extended indications of the technique. J Urol 1997 Aug;158(2):585-90. http://www.ncbi.nlm.nih.gov/pubmed/9224369
191. Mollard P, Mouriquand P, Joubert P. Urethral lengthening for neurogenic urinary incontinence (Kropp's procedure): results of 16 cases. J Urol 1990 Jan;143(1):95-7. http://www.ncbi.nlm.nih.gov/pubmed/2294274
192. Nill TG, Peller PA, Kropp KA. Management of urinary incontinence by bladder tube urethral lengthening and submucosal reimplantation. J Urol 1990 Aug;144(2 Pt 2):559-61; discussion 562-3. http://www.ncbi.nlm.nih.gov/pubmed/2374240
193. Rink RC, Adams MC, Keating MA. The flip-flap technique to lengthen the urethra (Salle procedure) for treatment of neurogenic urinary incontinence. J Urol 1994 Aug;152(2 Pt 2):799-802. http://www.ncbi.nlm.nih.gov/pubmed/8022018
194. Waters PR, Chehade NC, Kropp KA. Urethral lengthening and reimplantation: incidence and management of catheterization problems. J Urol 1997 Sep;158(3 Pt 2):1053-6. http://www.ncbi.nlm.nih.gov/pubmed/9258141
195. Diamond DA, Bauer SB, Dinlenc C, et al. Normal urodynamics in patients with bladder exstrophy: are they achievable? J Urol 1999 Sep;162(3 Pt 1):841-4; discussion 844-5. http://www.ncbi.nlm.nih.gov/pubmed/10458392
196. Hayes MC, Bulusu A, Terry T, et al. The Pippi Salle urethral lengthening procedure; experience and outcome from three United Kingdom centres. BJU Int 1999 Oct;84(6):701-5. http://www.ncbi.nlm.nih.gov/pubmed/10510119
197. Yerkes EB, Adams MC, Rink RC, et al. How well do patients with exstrophy actually void? J Urol 2000 Sep;164(3 Pt 2):1044-7. http://www.ncbi.nlm.nih.gov/pubmed/10958737
198. Surer I, Baker LA, Jeffs RD, et al. Modified Young-Dees-Leadbetter bladder neck reconstruction in patients with successful primary bladder closure elsewhere: a single institution experience. J Urol 2001 Jun;165(6 Pt 2):2438-40. http://www.ncbi.nlm.nih.gov/pubmed/11371993
199. Chan DY, Jeffs RD, Gearhart JP. Determinants of continence in the bladder exstrophy population: predictors of success? Urology 2001 Apr;57(4):774-7. http://www.ncbi.nlm.nih.gov/pubmed/11306402
200. Ferrer FA, Tadros YE, Gearhart J. Modified Young-Dees-Leadbetter bladder neck reconstruction: new concepts about old ideas. Urology 2001 Nov;58(5):791-6. http://www.ncbi.nlm.nih.gov/pubmed/11711366
201. Couvelaire R. [Bladder surgery]. Paris: Masson, 1955. [Article in French]
202. Cartwright PC, Snow BW. Bladder autoaugmentation: early clinical experience. J Urol 1989 Aug;142(2Pt 2):505-8; discussion 520-1. http://www.ncbi.nlm.nih.gov/pubmed/2746767
203. Stöhrer M, Kramer A, Goepel M, et al. Bladder auto-augmentation - an alternative for enterocystoplasty: preliminary results. Neurourol Urodyn 1995;14(1):11-23. [no abstract available] http://www.ncbi.nlm.nih.gov/pubmed/7742844
204. Elder JS. Autoaugmentation gastrocystoplasty: early clinical results. J Urol 1995 Jul;154(1):322-3. [no abstract available] http://www.ncbi.nlm.nih.gov/pubmed/7776450
205. Poppas DP, Uzzo RG, Britanisky RG, et al. Laparoscopic laser assisted auto-augmentation of the pediatric neurogenic bladder: early experience with urodynamic follow-up. J Urol 1996 Mar;155(3):1057-60. http://www.ncbi.nlm.nih.gov/pubmed/8583564
206. Snow BW, Cartwright PC. Bladder autoaugmentation. Urol Clin North Am 1996 May;23(2):323-31. http://www.ncbi.nlm.nih.gov/pubmed/8659030

207. Stöhrer M, Kramer G, Goepel M, et al. Bladder autoaugmentation in adult patients with neurogenic voiding dysfunction. Spinal Cord 1997 Jul;35(7):456-62.
http://www.ncbi.nlm.nih.gov/pubmed/9232751
208. Duel BP, Gonzalez R, Barthold JS. Alternative techniques for augmentation cystoplasty. J Urol 1998 Mar;159(3):998-1005.
http://www.ncbi.nlm.nih.gov/pubmed/9474216
209. Braren V, Bishop MR. Laparoscopic bladder autoaugmentation in children. Urol Clin North Am 1998 Aug;25(3):533-40.
http://www.ncbi.nlm.nih.gov/pubmed/9728222
210. Chapple CR, Bryan NP. Surgery for detrusor overactivity. World J Urol 1998;16(4):268-73.
http://www.ncbi.nlm.nih.gov/pubmed/9775426
211. Leng WW, Blalock HJ, Fredriksson WH, et al. Enterocystoplasty or detrusor myectomy? Comparison of indications and outcomes for bladder augmentation. J Urol 1999 Mar;161(3):758-63.
http://www.ncbi.nlm.nih.gov/pubmed/10022679
212. Comer MT, Thomas DF, Trejdosiewicz LK, et al. Reconstruction of the urinary bladder by auto augmentation, enterocystoplasty, and composite enterocystoplasty. Adv Exp Med Biol 1999; 462: 43-7. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/10599412
213. Siracusano S, Trombetta C, Liguori G, et al. Laparoscopic bladder auto-augmentation in an incomplete traumatic spinal cord injury. Spinal Cord 2000 Jan;38(1):59-61.
http://www.ncbi.nlm.nih.gov/pubmed/10762200
214. Oge O, Tekgul S, Ergen A, et al. Urothelium-preserving augmentation cystoplasty covered with a peritoneal flap. BJU Int 2000 May;85(7):802-5.
http://www.ncbi.nlm.nih.gov/pubmed/10792156
215. Cranidis A, Nestoridis G. Bladder augmentation. Int Urogynecol J Pelvic Floor Dysfunct 2000; 11(1):33-40.
http://www.ncbi.nlm.nih.gov/pubmed/10738932
216. Niknejad KG, Atala A. Bladder augmentation techniques in women. Int Urogynecol J Pelvic Floor Dysfunct 2000 Jun;11(3):156-69.
http://www.ncbi.nlm.nih.gov/pubmed/11484743
217. Westney OL, McGuire EJ. Surgical procedures for the treatment of urge incontinence. Tech Urol 2001 Jun;7(2):126-32.
http://www.ncbi.nlm.nih.gov/pubmed/11383990
218. Perovic SV, Djordjevic ML, Kekic ZK, et al. Bladder autoaugmentation with rectus muscle backing. J Urol 2002 Oct;168(4 Pt 2):1877-80.
http://www.ncbi.nlm.nih.gov/pubmed/12352380
219. Marte A, Di Meglio D, Cotrufo AM, et al. A long-term follow-up of autoaugmentation in myelodysplastic children. BJU Int 2002 Jun;89(9):928-31.
http://www.ncbi.nlm.nih.gov/pubmed/12010242
220. Ter Meulen PH, Heesakkers JP, Janknegt RA. A study on the feasibility of vesicomyotomy in patients with motor urge incontinence. Eur Urol 1997;32(2):166-9.
http://www.ncbi.nlm.nih.gov/pubmed/9286647
221. Potter JM, Duffy PG, Gordon EM, et al. Detrusor myotomy: a 5-year review in unstable and non-compliant bladders. BJU Int 2002 Jun;89(9):932-5.
http://www.ncbi.nlm.nih.gov/pubmed/12010243
222. Baskin LS, Kogan BA, Benard F. Treatment of infants with neurogenic bladder dysfunction using anticholinergic drugs and intermittent catheterisation. Br J Urol 1990 Nov;66(5):532-4.
http://www.ncbi.nlm.nih.gov/pubmed/2249125
223. Nagib A, Leal J, Voris HC. Successful control of selective anterior sacral rhizotomy for treatment of spastic bladder and ureteric reflux in paraplegics. Med Serv J Can 1966 Jul-Aug;22(7):576-81. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/5966992
224. Young B, Mulcahy JJ. Percutaneous sacral rhizotomy for neurogenic detrusor hyperreflexia. J Neurosurg 1980 Jul;53(1):85-7.
http://www.ncbi.nlm.nih.gov/pubmed/7411212
225. Franco I, Storrs B, Firlit CF, et al. Selective sacral rhizotomy in children with high pressure neurogenic bladders: preliminary results. J Urol 1992 Aug;148(2 Pt 2):648-50.
http://www.ncbi.nlm.nih.gov/pubmed/1640538
226. Schneidau T, Franco I, Zebold K, et al. Selective sacral rhizotomy for the management of neurogenic bladders in spina bifida patients: long-term followup. J Urol 1995 Aug;154(2 Pt 2):766-8.
http://www.ncbi.nlm.nih.gov/pubmed/7609174

227. Hohenfellner M, Pannek J, Bötel U, et al. Sacral bladder denervation for treatment of detrusor hyperreflexia and autonomic dysreflexia. Urology 2001 Jul;58(1):28-32. http://www.ncbi.nlm.nih.gov/pubmed/11445474
228. MacDonagh RP, Forster DM, Thomas DG. Urinary continence in spinal injury patients following complete sacral posterior rhizotomy. Br J Urol 1990 Dec;66(6):618-22. http://www.ncbi.nlm.nih.gov/pubmed/2265335
229. Sauerwein D, Ingunza W, Fischer J, et al. Extradural implantation of sacral anterior root stimulators. J Neurol Neurosurg Psychiatry 1990 Aug;53(8):681-4. http://www.ncbi.nlm.nih.gov/pubmed/2213045
230. Koldewijn EL, Van Kerrebroeck PE, Rosier PF, et al. Bladder compliance after posterior sacral root rhizotomies and anterior sacral root stimulation. J Urol 1994 Apr;151(4):955-60. http://www.ncbi.nlm.nih.gov/pubmed/8126835
231. Singh G, Thomas DG. Intravesical oxybutinin in patients with posterior rhizotomies and sacral anterior root stimulators. Neurourol Urodyn 1995;14(1):65-71. http://www.ncbi.nlm.nih.gov/pubmed/7742851
232. Van Kerrebroeck PE, Koldewijn EL, Rosier PF, et al. Results of the treatment of neurogenic bladder dysfunction in spinal cord injury by sacral posterior root rhizotomy and anterior sacral root stimulation. J Urol 1996 Apr;155(4):1378-81. http://www.ncbi.nlm.nih.gov/pubmed/8632580
233. Schurch B, Rodic B, Jeanmonod D. Posterior sacral rhizotomy and intradural anterior sacral root stimulation for treatment of the spastic bladder in spinal cord injured patients. J Urol 1997 Feb;157(2):610-4. http://www.ncbi.nlm.nih.gov/pubmed/8996369
234. Van Kerrebroeck EV, van der Aa HE, Bosch JL, et al. Sacral rhizotomies and electrical bladder stimulation in spinal cord injury. Part I: Clinical and urodynamic analysis. Dutch Study Group on Sacral Anterior Root Stimulation. Eur Urol 1997;31(3):263-71. http://www.ncbi.nlm.nih.gov/pubmed/9129914
235. Schumacher S, Bross S, Scheepe JR, et al. Restoration of bladder function in spastic neuropathic bladder using sacral deafferentation and different techniques of neurostimulation. Adv Exp Med Biol 1999;462:303-9. http://www.ncbi.nlm.nih.gov/pubmed/10599434
236. Van der Aa HE, Alleman E, Nene A, et al. Sacral anterior root stimulation for bladder control: clinical results. Arch Physiol Biochem 1999 Jul;107(3):248-56. http://www.ncbi.nlm.nih.gov/pubmed/10650355
237. Everaert K, Derie A, Van Laere M, et al. Bilateral S3 nerve stimulation, a minimally invasive alternative treatment for postoperative stress incontinence after implantation of an anterior root stimulator with posterior rhizotomy: a preliminary observation. Spinal Cord 2000 Apr;38(4):262-4. http://www.ncbi.nlm.nih.gov/pubmed/10822398
238. Creasey GH, Grill JH, Korsten M, et al; Implanted Neuroprosthesis Research Group. An implantable neuroprosthesis for restoring bladder and bowel control to patients with spinal cord injuries: a multicenter trial. Arch Phys Med Rehabil 2001 Nov;82(11):1512-9. http://www.ncbi.nlm.nih.gov/pubmed/11689969
239. Vignes JR, Liguoro D, Sesay M, et al. Dorsal rhizotomy with anterior sacral root stimulation for neurogenic bladder. Stereotact Funct Neurosurg 2001;76(3-4):243-5. http://www.ncbi.nlm.nih.gov/pubmed/12378103
240. Schumacher S, Bross S, Scheepe JR, et al. Extradural cold block for selective neurostimulation of the bladder: development of a new technique. J Urol 1999 Mar;161(3):950-4. http://www.ncbi.nlm.nih.gov/pubmed/10022732
241. Kirkham AP, Knight SL, Craggs MD, et al. Neuromodulation through sacral nerve roots 2 to 4 with a Finetech-Brindley sacral posterior and anterior root stimulator. Spinal Cord 2002 Jun;40(6): 272-81. http://www.ncbi.nlm.nih.gov/pubmed/12037708
242. Bhadra N, Grünewald V, Creasey G, et al. Selective suppression of sphincter activation during sacral anterior nerve root stimulation. Neurourol Urodyn 2002;21(1):55-64. http://www.ncbi.nlm.nih.gov/pubmed/11835425
243. Brindley GS. An implant to empty the bladder or close the urethra. J Neurol Neurosurg Psychiatry 1977 Apr;40(4):358-69. http://www.ncbi.nlm.nih.gov/pubmed/406364
244. Schmidt RA, Tanagho EA. Feasibility of controlled micturition through electric stimulation. Urol Int 1979;34(3):199-230. http://www.ncbi.nlm.nih.gov/pubmed/382559

245. Braun PM, Baezner H, Seif C, et al. Alterations of cortical electrical activity in patients with sacral neuromodulator. Eur Urol 2002 May;41(5):562-6; discussion 566-7.
http://www.ncbi.nlm.nih.gov/pubmed/12074800
246. Ruud Bosch JL, Groen J. Treatment of refractory urge urinary incontinence with sacral spinal nerve stimulation in multiple sclerosis patients. Lancet 1996 Sep;348(9029):717-9.
http://www.ncbi.nlm.nih.gov/pubmed/8806291
247. Bosch JL, Groen J. Neuromodulation: urodynamic effects of sacral (S3) spinal nerve stimulation in patients with detrusor instability or detrusor hyperreflexia. Behav Brain Res 1998 May;92(2):141-50.
http://www.ncbi.nlm.nih.gov/pubmed/9638956
248. Chartier-Kastler EJ, Ruud Bosch JL, Perrigot M, et al. Long-term results of sacral nerve stimulation (S3) for the treatment of neurogenic refractory urge incontinence related to detrusor hyperreflexia. J Urol 2000 Nov;164(5):1476-80.
http://www.ncbi.nlm.nih.gov/pubmed/11025686
249. Groen J, van Mastrigt R, Bosch JL. Computerized assessment of detrusor instability in patients treated with sacral neuromodulation. J Urol 2001 Jan;165(1):169-73.
http://www.ncbi.nlm.nih.gov/pubmed/11125389
250. Hohenfellner M, Humke J, Hampel C, et al. Chronic sacral neuromodulation for treatment of neurogenic bladder dysfunction: long-term results with unilateral implants. Urology 2001 Dec;58(6):887-92.
http://www.ncbi.nlm.nih.gov/pubmed/11744452
251. Haugland M, Sinkjaer T. Interfacing the body's own sensing receptors into neural prosthesis devices. Technol Health Care 1999;7(6):393-9.
http://www.ncbi.nlm.nih.gov/pubmed/10665672
252. Zhang YH, Shao QA, Wang JM. Enveloping the bladder with displacement of flap of the rectus abdominis muscle for the treatment of neurogenic bladder. J Urol 1990 Nov;144(5):1194-5.
http://www.ncbi.nlm.nih.gov/pubmed/2146404
253. Stenzl A, Ninkovic M, Kölle D, et al. Restoration of voluntary emptying of the bladder by transplantation of innervated free skeletal muscle. Lancet 1998 May;351(9114):1483-5.
http://www.ncbi.nlm.nih.gov/pubmed/9605805
254. Vajda P, Kaiser L, Magyarlaki T, et al. Histological findings after colocystoplasty and gastrocystoplasty. J Urol 2002 Aug;168(2):698-701; discussion 701.
http://www.ncbi.nlm.nih.gov/pubmed/12131353
255. Greenwell TJ, Venn SN, Mundy AR. Augmentation cystoplasty. BJU Int 2001 Oct;88(6):511-25.
http://www.ncbi.nlm.nih.gov/pubmed/11678743
256. Gough DC. Enterocystoplasty. BJU Int 2001 Nov;88(7):739-43.
http://www.ncbi.nlm.nih.gov/pubmed/11890246
257. Quek ML, Ginsberg DA. Long-term urodynamics followup of bladder augmentation for neurogenic bladder. J Urol 2003 Jan;169(1):195-8.
http://www.ncbi.nlm.nih.gov/pubmed/12478134
258. Chartier-Kastler EJ, Mongiat-Artus P, Bitker MO, et al. Long-term results of augmentation cystoplasty in spinal cord injury patients. Spinal Cord 2000 Aug;38(8):490-4.
http://www.ncbi.nlm.nih.gov/pubmed/10962609
259. Piechota HJ, Dahms SE, Probst M, et al. Functional rat bladder regeneration through xenotransplantation of the bladder acellular matrix graft. Br J Urol 1998 Apr;81(4):548-59.
http://www.ncbi.nlm.nih.gov/pubmed/9598626
260. Sievert KD, Tanagho EA. Organ-specific acellular matrix for reconstruction of the urinary tract. World J Urol 2000 Feb;18(1):19-25.
http://www.ncbi.nlm.nih.gov/pubmed/10766039
261. Kropp BP, Cheng EY. Bioengineering organs using small intestinal submucosa scaffolds: in vivo tissue-engineering technology. J Endourol 2000 Feb;14(1):59-62.
http://www.ncbi.nlm.nih.gov/pubmed/10735574
262. Liatsikos EN, Dinlenc CZ, Kapoor R, et al. Tissue expansion: a promising trend for reconstruction in urology. J Endourol 2000 Feb;14(1):93-6.
http://www.ncbi.nlm.nih.gov/pubmed/10735578
263. Reddy PP, Barrieras DJ, Wilson G, et al. Regeneration of functional bladder substitutes using large segment acellular matrix allografts in a porcine model. J Urol 2000 Sep;164(3 Pt 2):936-41.
http://www.ncbi.nlm.nih.gov/pubmed/10958712
264. Kawai K, Hattori K, Akaza H. Tissue-engineered artificial urothelium. World J Surg 2000 Oct;24(10):1160-2.
http://www.ncbi.nlm.nih.gov/pubmed/11071451

265. O'Donnell WF. Urological management in the patient with acute spinal cord injury. Crit Care Clin 1987 Jul;3(3):599-617.
http://www.ncbi.nlm.nih.gov/pubmed/3332216
266. Bennett JK, Gray M, Green BG, et al. Continent diversion and bladder augmentation in spinal cord-injured patients. Semin Urol 1992 May;10(2):121-32. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/1636071
267. Robertson CN, King LR. Bladder substitution in children. Urol Clin North Am 1986 May;13(2):333-44.
http://www.ncbi.nlm.nih.gov/pubmed/3515729
268. Duckett JW, Lotfi AH. Appendicovesicostomy (and variations) in bladder reconstruction. J Urol 1993 Mar;149(3):567-9.
http://www.ncbi.nlm.nih.gov/pubmed/8437267
269. Moreno JG, Chancellor MB, Karasick S, et al. Improved quality of life and sexuality with continent urinary diversion in quadriplegic women with umbilical stoma. Arch Phys Med Rehabil 1995 Aug;76(8):758-62.
http://www.ncbi.nlm.nih.gov/pubmed/7632132
270. Mollard P, Gauriau L, Bonnet JP, et al. Continent cystostomy (Mitrofanoff's procedure) for neurogenic bladder in children and adolescent (56 cases: long-term results). Eur J Pediatr Surg 1997 Feb;7(1): 34-7.
http://www.ncbi.nlm.nih.gov/pubmed/9085806
271. Sylora JA, Gonzalez R, Vaughn M, et al. Intermittent self-catheterization by quadriplegic patients via a catheterizable Mitrofanoff channel. J Urol 1997 Jan;157(1):48-50.
http://www.ncbi.nlm.nih.gov/pubmed/8976213
272. Cain MP, Casale AJ, King SJ, et al. Appendicovesicostomy and newer alternatives for the Mitrofanoff procedure: results in the last 100 patients at Riley Children's Hospital. J Urol 1999 Nov;162(5): 1749-52.
http://www.ncbi.nlm.nih.gov/pubmed/10524929
273. Stein R, Fisch M, Ermert A, et al. Urinary diversion and orthotopic bladder substitution in children and young adults with neurogenic bladder: a safe option for treatment? J Urol 2000 Feb;163(2):568-73.
http://www.ncbi.nlm.nih.gov/pubmed/10647686
274. Liard A, Séquier-Lipszyc E, Mathiot A, et al. The Mitrofanoff procedure: 20 years later. J Urol 2001 Jun;165(6 Pt 2):2394-8.
http://www.ncbi.nlm.nih.gov/pubmed/11371985
275. Kajbafzadeh AM, Chubak N. Simultaneous Malone antegrade continent enema and Mitrofanoff principle using the divided appendix: report of a new technique for prevention of stoma complications. J Urol 2001 Jun;165(6 Pt 2):2404-9.
http://www.ncbi.nlm.nih.gov/pubmed/11371987
276. Van Savage JG, Yepuri JN. Transverse retubularized sigmoidovesicostomy continent urinary diversion to the umbilicus. J Urol 2001 Aug;166(2):644-7.
http://www.ncbi.nlm.nih.gov/pubmed/11458110
277. Clark T, Pope JC 4th, Adams C, et al. Factors that influence outcomes of the Mitrofanoff and Malone antegrade continence enema reconstructive procedures in children. J Urol 2002 Oct;168(4 Pt 1): 1537-40; discussion 1540.
http://www.ncbi.nlm.nih.gov/pubmed/12352454
278. Richter F, Stock JA, Hanna MK. Continent vesicostomy in the absence of the appendix: three methods in 16 children. Urology 2002 Aug;60(2):329-34.
http://www.ncbi.nlm.nih.gov/pubmed/12137836
279. Shapiro SR, Lebowitz R, Colodny AH. Fate of 90 children with ileal conduit urinary diversion a decade later: analysis of complications, pyelography, renal function and bacteriology. J Urol 1975 Aug;114(2):289-95.
http://www.ncbi.nlm.nih.gov/pubmed/1159925
280. Hald T, Hebjøorn S. Vesicostomy - an alternative urine diversion operation. Long term results. Scand J Urol Nephrol 1978;12(3):227-31.
http://www.ncbi.nlm.nih.gov/pubmed/725543
281. Cass AS, Luxenberg M, Gleich P, et al. A 22-year followup of ileal conduits in children with a neurogenic bladder. J Urol 1984 Sep;132(2):529-31.
http://www.ncbi.nlm.nih.gov/pubmed/6471190
282. Schwartz SL, Kennelly MJ, McGuire EJ, et al. Incontinent ileo-vesicostomy urinary diversion in the treatment of lower urinary tract dysfunction. J Urol 1994 Jul;152(1):99-102.
http://www.ncbi.nlm.nih.gov/pubmed/8201699

283. Atan A, Konety BR, Nangia A, et al. Advantages and risks of ileovesicostomy for the management of neuropathic bladder. Urology 1999 Oct;54(4):636-40. http://www.ncbi.nlm.nih.gov/pubmed/10510920
284. Herschorn S, Rangaswamy S, Radomski SB. Urinary undiversion in adults with myelodysplasia: longterm followup. J Urol 1994 Aug;152(2 Pt 1):329-33. http://www.ncbi.nlm.nih.gov/pubmed/8015064

5. URINARY TRACT INFECTION IN NEUROGENIC LOWER URINARY TRACT DYSFUNCTION

5.1 Introduction

A detailed discussion of the clinical presentation, diagnosis, microbiological considerations and treatment strategies of complicated UTI can be found in the *EAU Guidelines on Urological Infections* (1). As stated in these guidelines, bacteriuria in patients with SCI should not be treated, even in cases of intermittent catheterisation. Generally, most knowledge concerning UTI in neurogenic patients comes from studies of patients with SCI and is therefore not directly transferable to other populations, such as MS, stroke, or PD.

5.2 Recurrent urinary tract infection in neurogenic patients

Recurrent UTI in patients with NLUTD may indicate a suboptimal management of the underlying functional problem, e.g. high bladder pressure during storage and voiding, incomplete voiding or bladder stones. The improvement of bladder function and the removal of bladder stones or other direct supporting factors are mandatory. Additionally, UTI prevention strategies can be applied (1).

5.3 Prevention

It is generally agreed that the best prevention of UTI in neurogenic patients is a well-balanced management of the LUTD, including low-pressure urine storage, maintaining a periodical, low resistance and ensuring complete voiding. If clean, intermittent catheterisation (CIC) is used for emptying, aseptic technique and sterile lubricated (2) or hydrophilic catheters (3,4) should be used. Regular voiding and a minimal daily fluid intake of 30 mL/kg body weight are considered to be supportive factors in UTI prevention.

Various approaches have been tried to minimise UTIs in neurogenic bladder. Randomised controlled trials have shown that cranberry extracts have no benefit (5-7). Research has also shown that both methenamine hippurate (8) and bladder irrigation are ineffective (9). Although urine acidification therapy using drugs, such as L-methionine, is widely used in neurogenic patients in an attempt to prevent UTIs, there is little scientific evidence to support its use. Low-dose, long-term, antibiotic prophylaxis may be an option for patients with recurrent UTI (10), but has the disadvantage of possibly increasing bacterial resistance (11). Vaccination therapy for UTI prevention has not been tested in neurogenic patients.

*5.3.1 **Recommendations for the treatment of urinary tract infection***

Recommendations	GR
Bacteriuria in patients with spinal cord injury should not be treated, even in cases of intermittent catheterisation.	
As in the general population, the use of long term antibiotics in recurrent UTIs may cause bacterial resistance and caution is advised.	
Protection of the urinary tract is the main focus.	

UTI = urinary tract infection.

5.4 References

1. Grabe M, Bjerklund-Johansen T-E, Botto H, et al; members of the European Association of Urology (EAU) Guidelines Office. Guidelines on Urological Infections. In: EAU Guidelines, edition presented at the 25th EAU Annual Congress 2010. ISBN 978-90-79754-70-0.

2. Giannantoni A, Di Stasi SM, Scivoletto G, et al. Intermittent catheterization with a prelubricated catheter in spinal cord injured patients: a prospective randomized crossover study. J Urol 2001 Jul;166(1):130-133.
http://www.ncbi.nlm.nih.gov/pubmed/11435839
3. De Ridder DJ, Everaert K, Fernández LG, et al. Intermittent catheterisation with hydrophilic-coated catheters (SpeediCath) reduces the risk of clinical urinary tract infection in spinal cord injured patients: a prospective randomised parallel comparative trial. Eur Urol 2005 Dec;48(6): 991-5.
http://www.ncbi.nlm.nih.gov/pubmed/16137822
4. Cardenas DD, Hoffman JM. Hydrophilic catheters versus noncoated catheters for reducing the incidence of urinary tract infections: a randomized controlled trial. Arch Phys Med Rehabil 2009 Oct;90(10):1668-71.
http://www.ncbi.nlm.nih.gov/pubmed/19801054
5. Linsenmeyer TA, Harrison B, Oakley A, et al. Evaluation of cranberry supplement for reduction of urinary tract infections in individuals with neurogenic bladders secondary to spinal cord injury. A prospective, double-blinded, placebo-controlled, crossover study. J Spinal Cord Med 2004;27(1): 29-34.
http://www.ncbi.nlm.nih.gov/pubmed/15156934
6. Waites KB, Canupp KC, Armstrong S, et al. Effect of cranberry extract on bacteriuria and pyuria in persons with neurogenic bladder secondary to spinal cord injury. J Spinal Cord Med 2004;27(1):35-40.
http://www.ncbi.nlm.nih.gov/pubmed/15156935
7. Hess MJ, Hess PE, Sullivan MR, et al. Evaluation of cranberry tablets for the prevention of urinary tract infections in spinal cord injured patients with neurogenic bladder. Spinal Cord 2008 Sep;46(9):622-6.
http://www.ncbi.nlm.nih.gov/pubmed/18392039
8. Lee BB, Haran MJ, Hunt LM, et al. Spinal-injured neuropathic bladder antisepsis (SINBA) trial. Spinal Cord 2007 Aug;45(8): 542-50.
http://www.ncbi.nlm.nih.gov/pubmed/17043681
9. Waites KB, Canupp KC, Roper JF, et al. Evaluation of 3 methods of bladder irrigation to treat bacteriuria in persons with neurogenic bladder. J Spinal Cord Med 2006;29(3):217-26.
http://www.ncbi.nlm.nih.gov/pubmed/16859225
10. Biering-Sorensen F, Hoiby N, Nordenbo A, et al. Ciprofloxacin as prophylaxis for urinary tract infection: prospective, randomized, cross-over, placebo controlled study in patients with spinal cord lesion. J Urol 1994 Jan;151(1):105-8.
http://www.ncbi.nlm.nih.gov/pubmed/8254783
11. Sandock DS, Gothe BG, Bodner DR. Trimethoprim-sulfamethoxazole prophylaxis against urinary tract infection in the chronic spinal cord injury patient. Paraplegia 1995 Mar;33(3): 156-60.
http://www.ncbi.nlm.nih.gov/pubmed/7784119

6. TREATMENT OF VESICO-URETERAL REFLUX

6.1 Treatment options

The treatment options for vesico-ureteral reflux in patients with NLUTD do not differ essentially from those in other reflux patients. They become necessary when the high intravesical pressure during the filling phase or during the voiding phase have been treated successfully, but where the reflux did not resolve (1-4). Subtrigonal injections with bulking agents or ureteral re-implantation are the standard procedures.

Subtrigonal injections of bulking agents: This minimal invasive procedure has a relatively good effect with complete success in about 65% of patients (5-12). It can also be easily repeated if not effective and thereby the success rate can be increased to about 75% after the second or third session.

Ureteral re-implantation: This technique has an immediate and long-lasting result in over 90% of the patients (11-13). In deciding which procedure will be offered to the patient, the relative risks of more invasive surgery and of less successful therapy should be considered.

6.2 References

1. Kass EJ, Koff SA, Diokno AC. Fate of vesicoureteral reflux in children with neuropathic bladders managed by intermittent catheterization. J Urol 1981 Jan;125(1):63-4. http://www.ncbi.nlm.nih.gov/pubmed/7463586
2. Sidi AA, Peng W, Gonzalez R. Vesicoureteral reflux in children with myelodysplasia: natural history and results of treatment. J Urol 1986 Jul;136(1 Pt 2):329-31. http://www.ncbi.nlm.nih.gov/pubmed/3723683
3. López Pereira P, Martinez Urrutia MJ, Lobato Romera R, et al. Should we treat vesicoureteral reflux in patients who simultaneously undergo bladder augmentation for neuropathic bladder? J Urol 2001 Jun;165(6 Pt 2):2259-61. http://www.ncbi.nlm.nih.gov/pubmed/11371958
4. Simforoosh N, Tabibi A, Basiri A, et al. Is ureteral reimplantation necessary during augmentation cystoplasty in patients with neurogenic bladder and vesicoureteral reflux? J Urol 2002 Oct;168(4 Pt 1): 1439-41. http://www.ncbi.nlm.nih.gov/pubmed/12352413
5. Diamond T, Boston VE. The natural history of vesicoureteric reflux in children with neuropathic bladder and open neural tube defects. Z Kinderchir 1987 Dec;42 Suppl 1:15-6. http://www.ncbi.nlm.nih.gov/pubmed/3433968
6. Chancellor MB, Rivas DA, Liberman SN, et al. Cystoscopic autogenous fat injection treatment of vesicoureteral reflux in spinal cord injury. J Am Paraplegia Soc 1994 Apr;17(2):50-4. http://www.ncbi.nlm.nih.gov/pubmed/8064286
7. Sugiyama T, Hashimoto K, Kiwamoto H, et al. Endoscopic correction of vesicoureteral reflux in patients with neurogenic bladder dysfunction. Int Urol Nephrol 1995;27(5):527-31. http://www.ncbi.nlm.nih.gov/pubmed/8775034
8. Misra D, Potts SR, Brown S, et al. Endoscopic treatment of vesico-ureteric reflux in neurogenic bladder-8 years' experience. J Pediatr Surg 1996 Sep;31(9):1262-4. http://www.ncbi.nlm.nih.gov/pubmed/8887097
9. Haferkamp A, Möhring K, Staehler G, et al. Long-term efficacy of subureteral collagen injection for endoscopic treatment of vesicoureteral reflux in neurogenic bladder cases. J Urol 2000 Jan;163(1):274-7. http://www.ncbi.nlm.nih.gov/pubmed/10604375
10. Shah N, Kabir MJ, Lane T, et al. Vesico-ureteric reflux in adults with neuropathic bladders treated with Polydimethylsiloxane (Macroplastique). Spinal Cord 2001 Feb;39(2):92-6. http://www.ncbi.nlm.nih.gov/pubmed/11402365
11. Engel JD, Palmer LS, Cheng EY, et al. Surgical versus endoscopic correction of vesicoureteral reflux in children with neurogenic bladder dysfunction. J Urol 1997 Jun;157(6):2291-4. http://www.ncbi.nlm.nih.gov/pubmed/9146655
12. Granata C, Buffa P, Di Rovasenda E, et al. Treatment of vesico-ureteric reflux in children with neuropathic bladder: a comparison of surgical and endoscopic correction. J Pediatr Surg 1999 Dec;34(12):1836-8. http://www.ncbi.nlm.nih.gov/pubmed/10626867
13. Kaplan WE, Firlit CF. Management of reflux in the myelodysplastic child. J Urol 1983 Jun;129(6): 1195-7. http://www.ncbi.nlm.nih.gov/pubmed/6854797

7. SEXUAL (DYS)FUNCTION AND FERTILITY

7.1 Spinal cord injury and sexuality - introduction

Neurological diseases and injuries have a distinct impact on sexual health, but guidelines for their management are still lacking (1). Periodical check-ups using validated questionnaires will help to assess and therefore improve sexual rehabilitation and response (2) (LE: 3).

7.2 Male sexuality: erectile dysfunction

7.2.1 Medical treatment - Phosphodiesterase type 5 inhibitors

Phosphodiesterase type 5 inhibitors (PDE5Is) are recommended as first-line treatment in men with SCI and ED. They are safe and effective for long-term use. The most common side-effects in men with SCI are headache and flushing, while men with tetraplegia or high-level paraplegia may have postural hypotension for several

hours after using a PDE5I.

Phosphodiesterase type 5 inhibitors are currently the first-line treatment option for ED in patients with SCI because of their high efficacy and safety rates (3-5) (LE: 1b). However, little is known about the effect on erectile function in neurological patients. Tadalafil and sildenafil citrate are effective and safe long-term treatments for patients with MS and PD, respectively (8-11) (LE: 1b).

The great majority of neurogenic patients require long-term therapy for ED. However, some patients have a low compliance rate or they stop therapy because of side-effects (3). In addition, some patients with severe neurological damage may be resistant to PDE5Is (12).

*7.2.2 **Mechanical devices***

Mechanical devices (vacuum tumescence devices and penile rings) may be effective but are less popular (6,7).

*7.2.3 **Intracavernosal injections***

Patients not responding to oral drugs may be offered intracavernosal injections. Intracavernosal penile injectable medications (ICI) are very effective for the treatment of ED in men with SCI, but their use requires careful dose titration and some precautions. The reported complications of intracavernous drugs include priapism and corpora cavernosa fibrosis.

An intracavernosal injection of vasoactive medication is the first therapeutic option to consider in patients taking nitrate medications, for whom there are concerns about drug interactions with PDE5Is, or in patients for whom PDE5Is are ineffective.

Topical agents for penile smooth muscle relaxation (prostaglandin) or intraurethral preparation of prostaglandin E1 (MUSE) were found to be less effective in SCI patients suffering from ED (13).

*7.2.4 **Penile prostheses***

Penile prostheses may be effective for treatment of ED in men with SCI and should be offered when all conservative treatments have failed. Serious complications, including infection and prosthesis perforation, may occur in about 10% of patients, depending on implant type (14-16).

*7.2.5 **Recommendations sexual dysfunction***

Recommendations	**GR**
Oral PDE5Is are the first-line treatment for erectile dysfunction in men with spinal cord injury.	A
Intracavernosal injections of vasoactive drugs (alone or in combination) are the second-line treatment when oral medications have failed.	A
Mechanical devices such as vacuum devices and rings may be effective but are not as popular.	C
Surgical prostheses should be reserved for selected patients who have not responded to conservative therapies.	B

7.3 Male fertility

Reproductive dysfunction in men with SCI is a common condition and is due to a combination of ED, ejaculatory failure, and abnormal semen parameters, even if the definitive causal mechanism is unknown (17) (LE: 3). Assisted reproductive technologies may be needed.

Pregnancy rates are lower than in the general population. But since the advent of intracytoplasmic sperm injection (ICSI) men with SCI now have a good chance of becoming biological fathers (18-20).

In men with retrograde ejaculation, the use of a balloon catheter to obstruct the bladder neck may be effective in obtaining antegrade ejaculation (21). More comparative trials are needed to evaluate the impact of intracavernosal injections on ejaculation and orgasmic function, their early use for increasing the recovery rate of a spontaneous erection, and their effectiveness and tolerability in the long-term (3). Prostatic massage is a safe and easy method to use for obtaining semen in men with lesions above T10 (22).

The two most commonly used methods of sperm retrieval are vibrostimulation (VS) and transrectal electroejaculation (EEJ) (23-25). Semen retrieval is more likely with VS in men with lesions above T10 (26-28).

Midodrine may be combined with VS in men not responding to VS alone. However, EEJ is the second choice for sperm retrieval when repeated tries at VS have failed (29).

Surgical procedures, such as epididymal (MESA) or testicular (TESE) sperm retrieval, may be used if VS and EEJ are not successful (30,31).

*7.3.1 **Sperm quality and motility***

The following has been reported about sperm quality and motility:

- Vibratory stimulation produces samples with better sperm motility than electrostimulation (24,32).
- Antegrade samples have better sperm motility than retrograde samples.
- EEJ with interrupted current produces better sperm motility than does continuous current (33).
- Bladder management with clean intermittent catheterisation may improve semen quality compared to indwelling catheterisation, reflex voiding or bladder expression (34).
- Sperm quality in patients with SCI is enhanced by processing in able-bodied seminal plasma (35).

There are no relevant publications about fertility in other neurological pathologies.

7.4 Female sexuality

Studies have shown that most women (65-80%) continue to be sexually active after SCI, but to a much lesser extent than before injury. In addition, about 25% of women with an SCI report a decreased satisfaction with their sexual life (37-39).

Studies show that the greatest physical barrier to sexual activity is urinary leakage. Problems with positioning and spasticity affect mainly tetraplegics. Peer support may help to optimise the sexual adjustment of women with SCI in achieving a more positive self-image, self-esteem and feelings of being attractive to themselves and others (40-43).

The use of specific drugs for sexual dysfunctions is indicated to treat inadequate lubrication. Sildenafil may partially reverse subjective sexual arousal difficulties, while manual and vibratory clitoral stimulation may increase genital responsiveness (44,45).

Neurophysiological studies have shown that women with the ability to perceive T11-L2 pinprick sensations may have psychogenic genital vasocongestion, while reflex lubrication and orgasm is more prevalent in women with SCI who have preserved the sacral reflex arc (S2-S5). These findings are true, even when it has not been shown in an individual woman that a specific level and degree of lesion is the cause of a particular sexual dysfunction. In SCI women with a complete lesion of the sacral reflex, arousal and orgasm may be evoked through stimulation of other erogenous zones above the level of lesions (46-48).

Studies have reported dissatisfaction with the quality and quantity of sexuality related rehabilitation services for women with SCI and that affected women were less likely to receive sexual information than men (48-50).

7.5 Female fertility

The reproductive capacity of women with SCI is only temporarily affected by SCI with cessation of menstruation for approximately 6 months post-SCI (51). About 70% of sexually active women use some form of contraception after injury, but fewer women use the birth control pill compared to before their injury (52).

Although pregnancy is usually normal, women with SCI are more likely to suffer complications during pregnancy, labour and delivery compared to able-bodied women. Complications of labour and delivery include bladder problems, spasticity, pressure sores, and anaemia autonomic dysreflexia (53,54). Obstetric outcomes include higher rates of caesarean sections and an increased incidence of low birth-weight babies (55).

Epidural anaesthesia is chosen and effective for most patients with autonomic dysreflexia during labour and delivery (56,57).

There is very little published data on women's experience of the menopause following an SCI (58).
There are no relevant publications about sexuality and fertility in other neurological pathologies.

7.6 References

1. Basson R, Rees P, Wang R, et al. Sexual function in chronic illness. J Sex Med 2010 Jan;7(1):374-88.
2. Lombardi G, Del Popolo G, Macchiarella A, et al. Sexual rehabilitation in women with spinal cord injury: a critical review of the literature. Spinal Cord 2010 Apr 13.) http://www.ncbi.nlm.nih.gov/pubmed/20386552
3. Lombardi G, Macchiarella A, Cecconi F, et al. Ten years of phosphodiesterase type 5 inhibitors in spinal cord injured patients. J Sex Med 2009 May;6(5):1248-58. http://www.ncbi.nlm.nih.gov/pubmed/19210710
4. Soler JM, Previnaire JG, Denys P, et al. Phosphodiesterase inhibitors in the treatment of erectile dysfunction in spinal cord-injured men. Spinal Cord 2007 Feb;45(2):169-73. http://www.ncbi.nlm.nih.gov/pubmed/16801935
5. Giuliano F, Rubio-Aurioles E, Kennelly M, et al. Vardenafil Study Group. Efficacy and safety of vardenafil in men with erectile dysfunction caused by spinal cord injury. Neurology 2006 Jan;66(2):210-6. http://www.ncbi.nlm.nih.gov/pubmed/16434656

6. Lombardi G, Macchiarella A, Del Popolo G. Efficacy and safety of tadalafil for erectile dysfunction in patients with multiple sclerosis. J Sex Med 2010 Jun;7(6):2192-200. http://www.ncbi.nlm.nih.gov/pubmed/20384939
7. Lombardi G, Macchiarella A, Cecconi F, et al. Efficacy and safety of medium and long-term tadalafil use in spinal cord patients with erectile dysfunction. J Sex Med 2009 Feb;6(2):535-43. http://www.ncbi.nlm.nih.gov/pubmed/19138363
8. Safarinejad MR, Taghva A, Shekarchi B, et al. Safety and efficacy of sildenafil citrate in the treatment of Parkinson-emergent erectile dysfunction: a double-blind, placebo-controlled, randomized study. Int J Impot Res 2010 Sep-Oct;22(5):325-35. http://www.ncbi.nlm.nih.gov/pubmed/20861846
9. Lombardi G, Macchiarella A, Cecconi F, et al. Ten-year follow-up of sildenafil use in spinal cord-injured patients with erectile dysfunction. J Sex Med 2009 Dec;6(12):3449-57. http://www.ncbi.nlm.nih.gov/pubmed/19686427
10. Hatzimouratidis K, Hatzichristou DG. Phosphodiesterase type 5 inhibitors: Unmet needs. Curr Pharm Des 2009 Oct;15(30):3476-85. http://www.ncbi.nlm.nih.gov/pubmed/19860693
11. Earle CM, Seah M, Coulden SE, et al. The use of the vacuum erection device in the management of erectile impotence. Int J Impot Res 1996 Dec;8(4):237-40 http://www.ncbi.nlm.nih.gov/pubmed/8981174
12. Denil J, Ohl DA, Smythe C. Vacuum erection device in spinal cord injured men: patient and partner satisfaction. Arch Phys Med Rehabil 1996 Aug;77(8):750-3. http://www.ncbi.nlm.nih.gov/pubmed/8702367
13. Bodner DR, Haas CA, Krueger B, et al. Intraurethral alprostadil for treatment of erectile dysfunction in patients with spinal cord injury. Urology 1999 Jan;53(1):199-202. http://www.ncbi.nlm.nih.gov/pubmed/9886612
14. Zermann DH, Kutzenberger J, Sauerwein D, et al. Penile prosthetic surgery in neurologically impaired patients: Long-term followup. J Urol 2006 Mar;175(3Pt1):1041-44. http://www.ncbi.nlm.nih.gov/pubmed/16469612
15. Gross AJ, Sauerwein DH, Kutzenberger J, et al. Penile prostheses in paraplegic men. Br J Urol 1996 Aug;78:262-4. http://www.ncbi.nlm.nih.gov/pubmed/8813925
16. Kimoto Y, Iwatsubo E. Penile prostheses for the management of the neuropathic bladder and sexual dysfunction in spinal cord injury patients: long term follow up. Paraplegia 1994 May;32(5):336-9. http://www.ncbi.nlm.nih.gov/pubmed/8058351
17. Patki P, Woodhouse J, Hamid R, et al. Effects of spinal cord injury on semen parameters. J Spinal Cord Med 2008;31(1):27-32. http://www.ncbi.nlm.nih.gov/pubmed/18533408
18. Taylor Z, Molloy D, Hill V, et al. Contribution of the assisted reproductive technologies to fertility in males suffering spinal cord injury. Aust N Z J Obstet Gynaecol 1999 Feb;39(1):84-7. http://www.ncbi.nlm.nih.gov/pubmed/10099757
19. Schatte EC, Orejuela FJ, Lipshultz LI, et al. Treatment of infertility due to anejaculation in the male with electroejaculation and intracytoplasmic sperm injection. J Urol 2000 Jun;163(6):1717-20. http://www.ncbi.nlm.nih.gov/pubmed/10799167
20. Shieh JY, Chen SU, Wang YH, et al. A protocol of electroejaculation and systematic assisted reproductive technology achieved high efficiency and efficacy for pregnancy for anejaculatory men with spinal cord injury. Arch Phys Med Rehabil 2003 Apr;84(4):535-40. http://www.ncbi.nlm.nih.gov/pubmed/12690592
21. Lim TC, Mallidis C, Hill ST, et al. A simple technique to prevent retrograde ejaculation during assisted ejaculation. Paraplegia 1994 Mar;32(3):142-9. http://www.ncbi.nlm.nih.gov/pubmed/8008416
22. Arafa MM, Zohdy WA, Shamloul R. Prostatic massage: a simple method of semen retrieval in men with spinal cord injury. Int J Androl 2007 Jun;30(3):170-3. http://www.ncbi.nlm.nih.gov/pubmed/17298549
23. Rutkowski SB, Geraghty TJ, Hagen DL, et al. A comprehensive approach to the management of male infertility following Spinal Cord Injury. Spinal Cord 1999 Jul;37(7):508-14 . http://www.ncbi.nlm.nih.gov/pubmed/10438118
24. Ohl DA, Sonksen J, Menge AC, et al. Electroejaculation versus vibratory stimulation in spinal cord injured men: sperm quality and patient preference. J Urol 1997 Jun;157(6):2147-9. http://www.ncbi.nlm.nih.gov/pubmed/9146603

25. Kolettis PN, Lambert MC, Hammond KR, et al. Fertility outcomes after electroejaculation in men with spinal cord injury. Fertil Steril 2002 Aug;78(2):429- 31. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/12137889
26. Beretta G, Chelo E, Zanollo A. Reproductive aspects in spinal cord injured males. Paraplegia 1989 Apr;27(2):113-8.
http://www.ncbi.nlm.nih.gov/pubmed/2717193
27. Sonksen J, Biering-Sorensen F, Kristensen JK, et al. Ejaculation induced by penile vibratory stimulation in men with spinal cord injuries. The importance of the vibratory amplitude. Paraplegia 1994 Oct;32(10):651-60.
http://www.ncbi.nlm.nih.gov/pubmed/7831070
28. Brackett NL, Kafetsoulis A, Ibrahim E, et al. Application of 2 vibrators salvages ejaculatory failures to 1 vibrator during penile vibratory stimulation in men with spinal cord injuries. J Urol 2007 Feb;177(2):660-3.
http://www.ncbi.nlm.nih.gov/pubmed/17222653
29. Soler JM, Previnaire JG, Plante P, et al. Mododrine improves ejaculation in spinal cord injured men. J Urol 2007 Nov;178(5):2082-6.
http://www.ncbi.nlm.nih.gov/pubmed/17869290
30. Brackett NL, Lynne CM, Ibrahim E, et al. Treatment of infertility in men with spinal cord injury. Nat Rev Urol 2010 Mar;7(3):162-72.
http://www.ncbi.nlm.nih.gov/pubmed/20157304
31. Dimitriadis F, Karakitsios K, Tsounapi P, et al. Erectile function and male reproduction in men with spinal cord injury: a review. Andrologia 2010 Jun;42(3):139-65.
http://www.ncbi.nlm.nih.gov/pubmed/20500744
32. Brackett NL, Padron OF, Lynne CM. Semen quality of spinal cord injured men is better when obtained by vibratory stimulation versus electroejaculation. J Urol 1997 Jan;157(1):151-7.
http://www.ncbi.nlm.nih.gov/pubmed/8976239
33. Brackett NL, Ead DN, Aballa TC, et al. Semen retrieval in men with spinal cord injury is improved by interrupting current delivery during electroejaculation. J Urol 2002 Jan;167(1):201-3.
http://www.ncbi.nlm.nih.gov/pubmed/11743305
34. Rutkowski SB, Middleton JW, Truman G, et al. The influence of bladder management on fertility in spinal cord injured males. Paraplegia 1995 May;33(5):263-6.
http://www.ncbi.nlm.nih.gov/pubmed/7630651
35. Brackett NL, Davi RC, Padron OF, et al. Seminal plasma of spinal cord injured men inhibits sperm motility of normal men. J Urol 1996 May;155(5):1632-5.
http://www.ncbi.nlm.nih.gov/pubmed/8627840
36. Brackett NL, Cohen DR, Ibrahim E, et al. Neutralization of cytokine activity at the receptor level improves sperm motility in men with spinal cord injuries. J Androl 2007 Sep-Oct;28(5):717-21.
http://www.ncbi.nlm.nih.gov/pubmed/17494103
37. Kreuter M, Sullivan M, Siösteen A. Sexual adjustment and quality of relationship in spinal paraplegia: a controlled study. Arch Phys Med Rehabil 1996 Jun; 77(6):541-8.
http://www.ncbi.nlm.nih.gov/pubmed/8831469
38. Jackson AB, Wadley V. A multicenter study of women's self reported reproductive health after spinal cord injury. Arch Phys Rehabil 1999 Nov;80(11):1420-8.
http://www.ncbi.nlm.nih.gov/pubmed/10569436
39. Kreuter M, Siösteen A, Biering-Sörensen F. Sexuality and sexual life in women with spinal cord injury: a controlled study. J Rehabil Med 2008 Jan;40(1):61-9.
http://www.ncbi.nlm.nih.gov/pubmed/18176739
40. Ferreiro-Velasco ME, Barca-Buyo A, de la Barrera SS, et al. Sexual issues in a sample of women with spinal cord injury. Spinal Cord 2005 Jan;43(1):51-5.
http://www.ncbi.nlm.nih.gov/pubmed/15303115
41. Westgren N, Hulting C, Levi R, et al. Sexuality in women with traumatic spinal cord injuries. Acta Obstet Gynecol Scand 1997 Nov;76(10):997-83.
http://www.ncbi.nlm.nih.gov/pubmed/9435740
42. Harrison J, Glass CA, Owens RG, et al. Factors associated with sexual functioning in women following spinal cord injury. Paraplegia 1995 Dec;33(12):687-92.
http://www.ncbi.nlm.nih.gov/pubmed/8927405
43. Reitz A, Tobe V, Knapp PA, Schurch B. Impact of spinal cord injury on sexual health and quality of life. Int J Impot Res 2004 Apr;16(2):167-74
http://www.ncbi.nlm.nih.gov/pubmed/14973522

44. Forsythe E, Horsewell JE. Sexual rehabilitation of women with a spinal cord injury. Spinal Cord 2006 Apr;44(4):234-1.
http://www.ncbi.nlm.nih.gov/pubmed/16172622
45. Sipski ML, Rosen RC, Alexander CJ, et al. Sildenafil effects on sexual and cardiovascular responses in women with spinal cord injury. Urology 2000 Jun;55(6):812-5.
http://www.ncbi.nlm.nih.gov/pubmed/10840082
46. Sipski ML, Alexander CJ, Rosen RC. Physiologic parameters associated with sexual arousal in women with incomplete spinal cord injuries. Arch Phys Med Rehabil 1997 Mar;78(3):305-13.
http://www.ncbi.nlm.nih.gov/pubmed/9084355
47. Sipski ML, Alexander CJ, Rosen RC. Sexual arousal and orgasm in women: effect of spinal cord injury. Ann Neurol 2001 Jan;49(1):35-44.
http://www.ncbi.nlm.nih.gov/pubmed/11198294
48. Alexander M, Rosen RC. Spinal cord injuries and orgasm: a review. J Sex Marital Ther 2008;34(4): 308-24.
http://www.ncbi.nlm.nih.gov/pubmed/18576233
49. McAlonan S. Improving sexual rehabilitation services: the patient's perspective. Am J Occup Ther 1996 Nov-Dec;50(10):826-34.
http://www.ncbi.nlm.nih.gov/pubmed/8947375
50. Schopp LH, Hirkpatrick HA, Sanford TC, et al. Impact of comprehensive gynecologic services on health maintenance behaviours among women with spinal cord injury. Disabil Rehabil 2002 Nov;24(17):899-903.
http://www.ncbi.nlm.nih.gov/pubmed/12519485
51. Axel SJ. Spinal cord injured women's concerns: Menstruation and pregnancy. Rehabil Nurs 1982 Sep-Oct;7(5):10-5. [no abstract available]
http://www.ncbi.nlm.nih.gov/pubmed/6921826
52. Jackson AB, Wadley V. A multicenter study of women's self-reported reproductive health after spinal cord injury. Arch Phys Med Rehabil 1999 Nov;80(11):1420-8.
http://www.ncbi.nlm.nih.gov/pubmed/10569436
53. Baker ER, Cardenas DD. Pregnancy in spinal cord injured women. Arch Phys Med Rehabil 1996 May;77(5):501-7.
http://www.ncbi.nlm.nih.gov/pubmed/8629929
54. Baker ER, Cardenas DD, Benedetti TJ. Risks associated with pregnancy in spinal cord-injured women. Obstet Gynecol 1992 Sep;80(3Pt1):425-8.
http://www.ncbi.nlm.nih.gov/pubmed/1495699
55. Jackson AB, Wadley V. A multicenter study of women's self-reported reproductive health after spinal cord injury. Arch Phys Med Rehabil 1999 Nov;80(11):1420-8.
http://www.ncbi.nlm.nih.gov/pubmed/10569436
56. Cross LL, Meythaler JM, Tuel SM, et al. Pregnancy, labor and delivery post spinal cord injury. Paraplegia 1992 Dec;30(12):890-902.
http://www.ncbi.nlm.nih.gov/pubmed/1287543
57. Hughes SJ, Short DJ, Usherwood MM, et al. Management of the pregnant woman with spinal cord injuries. Br J Obstet Gynaecol 1991 Jun;98(6):513-8.
http://www.ncbi.nlm.nih.gov/pubmed/1873238
58. Dannels A, Charlifue S. The perimenopause experience for women with spinal cord injuries. SCI Nurs 2004 Spring;21(1):9-13.
http://www.ncbi.nlm.nih.gov/pubmed/15176344

8. QUALITY OF LIFE

8.1 Introduction

Quality of life (QoL) is a very important aspect of the overall management of NLUTD patients (1). The type of bladder management may influence the health-related QoL (HRQoL) in patients with SCI (2). The effectiveness of urological treatment and the urodynamic functionality of the neurogenic bladder have become increasingly determinant of patient QoL (3). QoL is a reflection of the individual's ability to cope with the new life situation (4). Despite the limitations associated with neurological pathology, adequate treatment is possible in most patients and should not interfere with social independence. QoL can be influenced by several factors including family support, adjustment and coping ability, productivity, self-esteem, financial stability, education, and the

physical and social environment (5) (LE: 3). Age, sex, ethnicity, and the patient's acceptance of the condition should also be taken into consideration when assessing QoL (6) (LE: 3).

8.2 Quality of life assessment

There are no specific QoL questionnaires for neurogenic bladder dysfunction or NLUTD. The only validated tools are a generic Visual Analogue Scale (VAS) for symptom bother, and Qualiveen® which is a specific tool for QoL in spinal cord lesion and multiple sclerosis patients. Qualiveen appears to be a discriminative evaluation instrument (3,7-9) and a short form is now available (10).

More commonly, QoL is assessed secondarily by generic HRQoL questionnaires such as the Incontinence Quality of Life Instrument (I-QOL), King's Health Questionnaire (KHQ), Short Form 36 Health Survey Questionnaire (SF-36), Euro Quality of Life-5 Domains (EQ-5D), Short Form 6D Health Survey Questionnaire (SF-6D), or the Health Utilities Index (HUI).

Furthermore, the quality-adjusted life year (QALY) metric quantifies patient outcomes, by weighting years of life spent in a specified health state by a factor representing the value that society or patients place on that health state (11) (LE: 3).

8.3 Therapy influence on quality of life

Appropriate therapies should manage symptoms, improve urodynamic parameters, functional abilities and QoL, and avoid secondary complications (8,12). Changes in NLUTD appear to be a major determinant of patient QoL (13,14) (LE: 2a).

8.4 Conclusions and recommendations

Conclusions	LE
One of the main aims of therapy is to improve qualify of life.	1
There is a lack of disease-specific outcome measures assessing HRQoL in patients with NLUTD.	

Recommendations	GR
Quality of life should be assessed when evaluating lower urinary tract symptoms in neurogenic patients and when treating neurogenic bowel dysfunction.	B
The available validated tools are Qualiveen, a specific long- and short-form tool for spinal cord lesion and multiple sclerosis patients and VAS for symptom bother. In addition, generic (SF-36) or specific tools for incontinence (I-QOL) questionnaires can be used.	B

8.5 References

1. Stöhrer M, Blok B, Castro-Diaz D, et al. EAU guidelines on neurogenic lower urinary tract dysfunction. Eur Urol 2009 Jul;56(1):81-8. http://www.ncbi.nlm.nih.gov/pubmed/19403235
2. Liu CW, Attar KH, Gall A, et al. The relationship between bladder management and health-related quality of life in patients with spinal cord injury in the UK. Spinal Cord 2010 Apr;48(4):319-24. http://www.ncbi.nlm.nih.gov/pubmed/19841636
3. Pannek J, Kullik B. Does optimizing bladder management equal optimizing quality of life? Correlation between health-related quality of life and urodynamic parameters in patients with spinal cord lesions. Urology 2009 Aug;74(2):263-6. http://www.ncbi.nlm.nih.gov/pubmed/19428089
4. Ku JH. The management of neurogenic bladder and quality of life in spinal cord injury. BJU Int 2006 Oct;98(4):739-45. http://www.ncbi.nlm.nih.gov/pubmed/16978269
5. Whiteneck G, Meade MA, Dijkers M, et al. Environmental factors and their role in participation and life satisfaction after spinal cord injury. Arch Phys Med Rehabil 2004 Nov;85(11):1793-803. http://www.ncbi.nlm.nih.gov/pubmed/15520974
6. Marschall-Kehrel D, Roberts RG, Brubaker L. Patient-reported outcomes in overactive bladder: the influence of perception of condition and expectation for treatment benefit. Urology 2006 Aug:68(2Suppl):29-37. http://www.ncbi.nlm.nih.gov/pubmed/16908338

7. Bonniaud V, Jackowski D, Parratte B, et al. Quality of life in multiple sclerosis patients with urinary disorders: discriminative validation of the English version of Qualiveen. Qual Life Res 2005 Mar;14(2):425-31.
http://www.ncbi.nlm.nih.gov/pubmed/15892431
8. Pappalardo A, Patti F, Reggio A. Management of neuropathic bladder in multiple sclerosis. Clin Ter 2004 May;155(5):183-6.
http://www.ncbi.nlm.nih.gov/pubmed/15344566
9. Bonniaud V, Bryant D, Parratte B, et al. Qualiveen, a urinary-disorder specific instrument: 0.5 corresponds to the minimal important difference. J Clin Epidemiol 2008 May;61(5):505-10.
http://www.ncbi.nlm.nih.gov/pubmed/18394545
10. Bonniaud V, Bryant D, Parratte B, et al. Development and validation of the short form of a urinary quality of life questionnaire: SF-Qualiveen. J Urol 2008 Dec;180(6):2592-8.
http://www.ncbi.nlm.nih.gov/pubmed/18950816
11. Hollingworth W, Campbell JD, Kowalski J, et al. Exploring the impact of changes in neurogenic urinary incontinence frequency and condition-specific quality of life on preference-based outcomes. Qual Life Res 2010 Apr;19(3):323-31.
http://www.ncbi.nlm.nih.gov/pubmed/20094804
12. Kuo HC. Therapeutic satisfaction and dissatisfaction in patients with spinal cord lesions and detrusor sphincter dyssynergia who received detrusor botulinum toxin a injection. Urology 2008 Nov;72(5):1056-60.
http://www.ncbi.nlm.nih.gov/pubmed/18533231
13. Henze T. Managing specific symptoms in people with multiple sclerosis. Int MS J 2005 Aug;12(2): 60-8.
http://www.ncbi.nlm.nih.gov/pubmed/16417816
14. Kalsi V, Apostolidis A, Popat R, et al. Quality of life changes in patients with neurogenic versus idiopathic detrusor overactivity after intradetrusor injections of botulinum neurotoxin type A and correlations with lower urinary tract symptoms and urodynamic changes. Eur Urol 2006 Mar;49(3): 528-35.
http://www.ncbi.nlm.nih.gov/pubmed/16426735

9. FOLLOW-UP

9.1 Introduction

Neurogenic lower urinary tract dysfunction is an unstable condition and can vary considerably, even within a relatively short period. Meticulous follow-up and regular checks are necessary (1-20). Depending on the type of the underlying neurological pathology and on the current stability of the NLUTD, the interval between the detailed investigations should not exceed 1-2 years. In patients with multiple sclerosis and in acute SCI, this interval is of course much smaller. Urine dip sticks should be available for the patient and urinalysis should be performed at least every second month. The upper urinary tract, the bladder shape, and residual urine should be checked every 6 months. Physical examination and blood and urine laboratory should take place every year. Any sign indicating a risk factor warrants specialised investigation.

9.2 Guidelines for follow-up

Possible UTI checked by the patient (dip stick).
Urinalysis every second month.
Upper urinary tract, bladder morphology, and residual urine every 6 months (ultrasound).
Physical examination, blood chemistry, and urine laboratory every year.
Detailed specialistic investigation every 1-2 years and on demand when risk factors emerge. The investigation is specified according to the patient's actual risk profile, but should in any case include a video-urodynamic investigation and should be performed in a leading neuro-urological centre.
All of the above should be more frequent if the neurological pathology or the NLUTD status demand this.

UTI = urinary tract infection; NLUTD = neurogenic lower urinary tract dysfunction.

9.3 References

1. Stöhrer M. Alterations in the urinary tract after spinal cord injury-diagnosis, prevention and therapy of late sequelae. World J Urol 1990;7(4):205-211. http://www.springerlink.com/content/k16411w744170641/fulltext.pdf
2. Perkash I. Long-term urologic management of the patient with spinal cord injury. Urol Clin North Am 1993 Aug;20(3):423-34. http://www.ncbi.nlm.nih.gov/pubmed/8351768
3. Selzman AA, Elder JS, Mapstone TB. Urologic consequences of myelodysplasia and other congenital abnormalities of the spinal cord. Urol Clin North Am 1993;20(3):485-504. http://www.ncbi.nlm.nih.gov/pubmed/8351774
4. Stöhrer M, Kramer G, Löchner-Ernst D, et al. Diagnosis and treatment of bladder dysfunction in spinal cord injury patients. Eur Urol Update Series 1994;3:170-5.
5. Thon WF, Denil J, Stief CG, et al. [Long-term care of patients with meningomyelocele. II. Theraphy]. Aktuel Urol 25:63-76. [Article in German]
6. Waites KB, Canupp KC, DeVivo MJ, et al. Compliance with annual urologic evaluations and preservation of renal function in persons with spinal cord injury. J Spinal Cord Med 1995 Oct;18(4): 251-4. http://www.ncbi.nlm.nih.gov/pubmed/8591072
7. Cardenas DD, Mayo ME, Turner LR. Lower urinary changes over time in suprasacral spinal cord injury. Paraplegia 1995 Jun;33(6):326-9. http://www.ncbi.nlm.nih.gov/pubmed/7644258
8. Capitanucci ML, Iacobelli BD, Silveri M, et al. Long-term urological follow-up of occult spinal dysraphism in children. Eur J Pediatr Surg 1996 Dec;6 Suppl 1:25-6. http://www.ncbi.nlm.nih.gov/pubmed/9008815
9. Chua HC, Tow A, Tan ES. The neurogenic bladder in spinal cord injury-pattern and management. Ann Acad Med Singapore 1996 Jul;25(4):553-7. http://www.ncbi.nlm.nih.gov/pubmed/8893929
10. Agarwal SK, Bagli DJ. Neurogenic bladder. Indian J Pediatr 1997 May-Jun;64(3):313-26. http://www.ncbi.nlm.nih.gov/pubmed/10771853
11. Rashid TM, Hollander JB. Multiple sclerosis and the neurogenic bladder. Phys Med Rehabil Clin N Am 1998 Aug;9(3):615-29. http://www.ncbi.nlm.nih.gov/pubmed/9894113
12. Burgdorfer H, Heidler H, Madersbacher H, et al. [Guidelines for the urological care of paraplegics]. Urologe A 1998;37:222-8. [Article in German]
13. McKinley WO, Jackson AB, Cardenas DD, et al. Long-term medical complications after traumatic spinal cord injury: a regional model systems analysis. Arch Phys Med Rehabil 1999 Nov;80(11): 1402-10. http://www.ncbi.nlm.nih.gov/pubmed/10569434
14. Atan A, Konety BR, Nangia A, et al. Advantages and risks of ileovesicostomy for the management of neuropathic bladder. Urology 1999 Oct;54(4):636-40. http://www.ncbi.nlm.nih.gov/pubmed/10510920
15. Cranidis A, Nestoridis G. Bladder augmentation. Int Urogynecol J Pelvic Floor Dysfunct 2000; 11(1):33-40. http://www.ncbi.nlm.nih.gov/pubmed/10738932
16. Elliott DS, Boone TB. Recent advances in the management of the neurogenic bladder. Urology 2000 Dec;56 (6 Suppl 1):76-81. http://www.ncbi.nlm.nih.gov/pubmed/11114567
17. Chen Y, DeVivo MJ, Roseman JM. Current trend and risk factors for kidney stones in persons with spinal cord injury: a longitudinal study. Spinal Cord 2000 Jun;38(6):346-53. http://www.ncbi.nlm.nih.gov/pubmed/10889563
18. Lawrenson R, Wyndaele JJ, Vlachonikolis I, et al. Renal failure in patients with neurogenic lower urinary tract dysfunction. Neuroepidemiology 2001 May;20(2):138-43. http://www.ncbi.nlm.nih.gov/pubmed/11359083
19. Ciancio SJ, Mutchnik SE, Rivera VM, et al. Urodynamic pattern changes in multiple sclerosis. Urology 2001 Feb;57(2):239-45. http://www.ncbi.nlm.nih.gov/pubmed/11182328
20. Burns AS, Rivas DA, Ditunno JF. The management of neurogenic bladder and sexual dysfunction after spinal cord injury. Spine 2001 Dec;26 (24 Suppl):S129-36. http://www.ncbi.nlm.nih.gov/pubmed/11805620

10. CONCLUSIONS

Neurogenic lower urinary tract dysfunction is a multi-faceted pathology. It requires an extensive and specific diagnosis before one can embark on an individualised therapy, which takes into account the medical and physical condition of the patient and the patient's expectations about his future social and physical situation with respect to the NLUTD.

The urologist or paediatric urologist can select from a wealth of therapeutical options, each with its own pros and cons. Notwithstanding the success of any therapy embarked upon, a close surveillance is necessary for the patient's entire life.

With these guidelines, we offer you expert advice on how to define the patient's NLUTD condition as precisely as possible and how to select, together with the patient, the appropriate therapy. This last choice, as always, is governed by the golden rule: as effective as needed, as less invasive as possible.

11. ABBREVIATIONS USED IN THE TEXT

This list is not comprehensive for the most common abbreviations

CVA	cerebrovascular
DLPP	detrusor leak point pressure
DO	detrusor overactivity
DSD	detrusor sphincter dyssynergia
EEJ	electroejaculation
EMG	electromyography, electromyogram
FVC	frequency volume chart
HIV	human immunodeficiency virus
HRQoL	health-related quality of life
IC	intermittent catheterisation
ISC	intermittent self-catheterisation
ICS	international Continence Society
LPP	leak point pressure
LMNL	lower motor neuron lesion
LUT	lower urinary tract
LUTD	lower urinary tract dysfunction
LUTS	lower urinary tract symptoms
MTC	micturition time chart
NDO	neurogenic detrusor overactivity
NLUTD	neurogenic lower urinary tract dysfunction
PNE	percutaneous nerve evaluation test
QoL	quality of life
SARS	sacral anterior root stimulation
SCI	spinal cord injury
SDAF	sacral deafferentation
SLE	systemic lupus erythematosus
UMNL	upper motor neuron lesion
UTI	urinary tract infection
VAS	visual analogue scale
VS	vibrostimulation

Conflict of interest

All members of the Neurogenic Lower Urinary Tract Dysfunction Guidelines working panel have provided disclosure statements on all relationships that they have that might be perceived to be a potential source of a conflict of interest. This information is publically accessible through the European Association of Urology website. This guidelines document was developed with the financial support of the European Association of Urology. No external sources of funding and support have been involved. The EAU is a non-profit organisation, and funding is limited to administrative assistance and travel and meeting expenses. No honoraria or other reimbursements have been provided.