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Follow-up of the neuro-urological patient: a systematic review

Marcio Augusto Averbeck and Helmut Madersbacher*

*Department of Urology, Mae de Deus Center Hospital, Porto Alegre, Brazil, and *Department of Neurology, University Hospital Innsbruck, Innsbruck, Austria*

Objectives

To systematically review the long-term urological follow-up strategies for patients with neurogenic lower urinary tract dysfunction (NLUTD), focusing on three main groups of neurological diseases: (i) spinal cord injuries, (ii) spinal dysraphism, and (iii) multiple sclerosis.

Patients and Methods

Data acquisition comprised electronic search on the Medical Literature Analysis and Retrieval System Online (MEDLINE) database and the EMBASE database in August 2014 to retrieve English language studies. MEDLINE and EMBASE search included the following medical subject heading (MeSH) terms: (i) neurogenic bladder and (ii) neurogenic bladder dysfunction. Each of these terms was crossed with (i) long-term care and (ii) long-term surveillance. Only studies related to NLUTD and urological follow-up were included. Studies were also identified by hand search of reference lists and review articles.

Results

Initial records identified through database searching included 265 articles. In all, 23 articles were included in the quantitative synthesis. The proposed time schedule of investigations as well as the amount and type of investigation were different according to specific neurological lesions. They depend on the dysfunctional pattern of the lower urinary tract (LUT) and its risk profile. However, there is a lack of high-evidence level studies to support an optimal long-term follow-up protocol.

Conclusions

The goal of neuro-urological management is the best possible preservation of upper urinary tract (UUT) and LUT function in relation to the individual neurological disorder. Regular and risk adapted controls ('urochecks') allow detection of risk-factors in time before irreversible changes of the LUT and UUT have occurred. With risk- and patient-oriented lifelong regular urological care an optimised quality of life and life-expectancy can be achieved, although there is a complete lack of high-evidence level studies on this topic.

Keywords

neurogenic bladder, long-term care, urological diagnostic techniques

Introduction

Neurogenic lower urinary tract dysfunction (NLUTD) is not a static condition but follows its own natural history that can manifest in changes of the lower urinary tract (LUT) and upper urinary tract (UUT), firstly functional, later morphological, and may also affect, mostly deteriorate, sexual and bowel function.

The aetiology and the underlying pathophysiology of NLUTD are mainly responsible for the different risk profiles for LUT and UUT deterioration, which may be further influenced by age, gender and last but not least by the patient's self-discipline. Therefore it is understandable that there are no guidelines on long-term care that can be applied to all of these patients. They mostly focus on special patients groups, e.g. on spinal cord injuries (SCIs) [1–5] or patients with multiple sclerosis (MS) [6,7]. Therefore, also the intervals in which controls should be performed are different and depend very much on the current (actual) findings.

One prerequisite for effective long-term care is the information of the patient about 'her/his neurogenic bladder' and the impact of this condition on health, way of life and sexuality. Moreover, the patient should be informed about the pros and cons of various treatment options, including costs, as well as about the necessity that experts should be consulted when urological problems arise.

The aim of the present study was to systematically review the long-term urological follow-up strategies for patients with NLUTD, focusing on what should be included as general and/or specific investigations, and on what should the optimal time schedule for controls, according to three main groups of neurological diseases: (i) SCI, (ii) spinal dysraphism, and (iii) MS.

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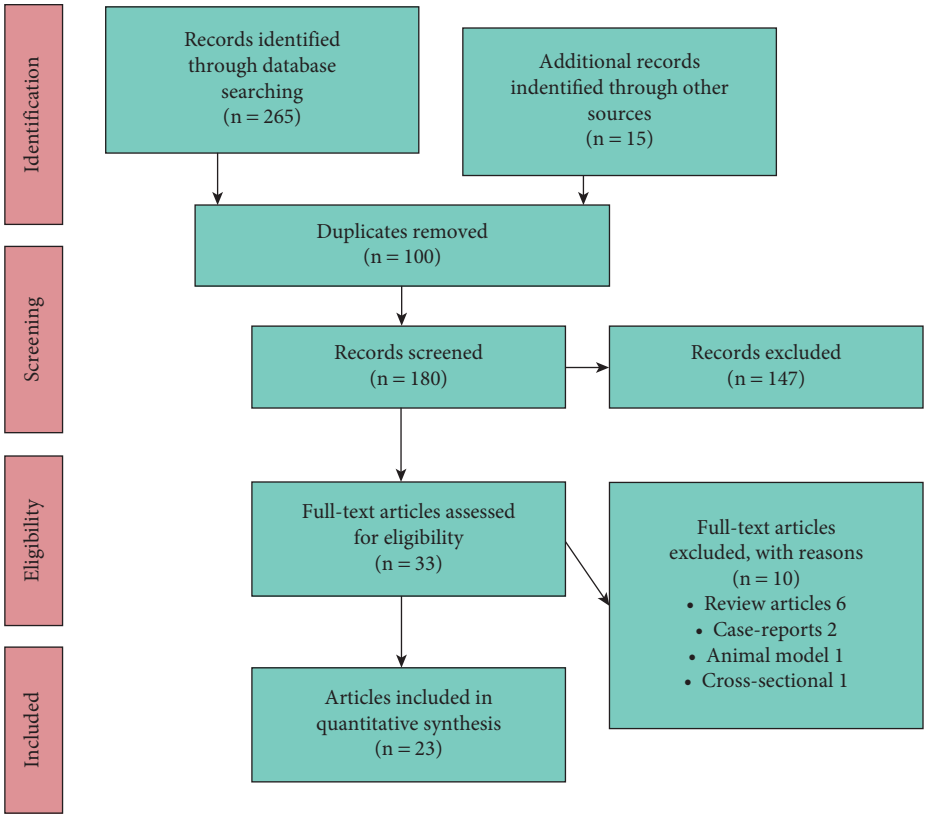

Fig. 1 Flow diagram of follow-up studies of the neuro-urological patient.

Patients and Methods

This systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement [8]. Data acquisition comprised electronic search on MEDLINE and EMBASE databases in August 2014 to retrieve English language studies. Medical subject heading (MeSH) terms included: (i) neurogenic bladder and (ii) neurogenic bladder dysfunction. Each of these terms was crossed with (i) long-term care and (ii) long-term surveillance. Only studies related to NLUTD and urological follow-up were included into this review article. Studies were also identified by hand search of reference lists and review articles.

Results

Initial records identified through database searching included 265 articles; 15 additional records were identified through other sources. The study selection procedure is described in Fig. 1.

After duplicates removal ($n = 100$), 147 of 180 screened articles were excluded because they were not related to the neuro-urological follow-up. In all, 23 of 33 full-text articles were included in the quantitative synthesis [1–7,9–24]. Thus, 10 articles were excluded because they did not bring additional information on the neuro-urological follow-up (six review articles, two case-reports, one animal model, one cross-sectional study) [25–34].

Most studies were focused on SCI (13 articles), spinal dysraphism (threee articles), and MS (twoarticles). Main results are presented on Table 1 [9–21].

Follow-up in Patients with SCI

In a comparative study to determine compliance with annual urological evaluations and renal function preservation in patients with SCI, Waites et al. [9] found that although serial examination of the urinary tract after SCI is important, nonetheless it might be acceptable to lengthen the periods between examinations after the first few years.

Yet, for LUT changes over time in suprasacral SCI, Cardenas et al. [10] compared video-urodynamic (VUD) findings with methods of bladder management. Maximum detrusor pressure decreased significantly over time for patients on external collectors ($P < 0.01$). Tests also indicated more severe bladder trabeculation in this group. It was concluded the results may reflect the effects of age, as well as reduced survival in those using external collectors with chronically elevated detrusor pressure.

McKinley et al. [11] analysed the incidence, risk factors, and trends of long-term secondary medical complications in patients with SCI, who had annual evaluations. The incidence

Table 1 Main results of studies on neuro-urological follow-up.

Reference	Publication year	Study type	LE	*n*	Most relevant results
Waites et al. [9]	1995	Prospective cohort	4	59	Serial examination of the urinary tract after SCI is important but that it might be acceptable to lengthen the periods between examinations after the first few years.
Cardenas et al. [10]	1995	Cross-sectional	3b	179	Patients who had external collector as bladder management were more likely to have severe bladder trabeculation due to chronically elevated detrusor pressure, when compared with patients on catheterisation.
McKinley et al. [11]	1999	Retrospective cohort	4	NR	Incidence of urinary stones was higher in patients with complete tetraplegia. Compliance with IC became less common at later follow-up.
Chen et al. [12]	2000	Cohort study (database estimative)	2b	8314	Within 10 years after injury, 7% of patients with SCI would develop their first kidney stone. The risk was greatest during the first 3 months after injury (31 cases per 1000 person-years).
Bartel et al. [13]	2014	Retrospective cohort	3b	93	Bladder stones were identified with suprapubic catheter in 11% (50/453), transurethral catheter in 6.6% (5/75), with IC in 2% (27/1315) and with reflex micturition in 1.1% (11/982), respectively. The mean time to stone development was 95 months.
Zhang and Liao [14]	2014	Prospective cohort	4	112	Lumbosacral SCI and chronic indwelling urethral and suprapubic catheterisation were predictors of UUT deterioration.
Capitanucci et al. [15]	1996	Prospective cohort	4	65	At long-term follow-up (2–14 years), UUT deterioration occurred in 15% and renal failure in 7.5% of children with occult spinal dysraphism.
Vainrib et al. [16]	2013	Retrospective cohort	4	118	Myelomeningocele patients should be followed in the long-run, even after bladder augmentation, as elevated detrusor pressures can still be seen.
Ciancio et al. [17]	2001	Retrospective cohort	4	22	A significant proportion of patients with MS with and without new urinary symptoms will develop changes in their underlying urodynamic patterns and detrusor compliance during a mean follow-up of 42 months.
Wiedemann et al. [18]	2013	Cross-sectional	3b	100	UDS showed urinary tract dysfunction in 78% of patients with MS with LUTS. Risk factors for pathological urodynamic findings were wheelchair dependency, use of more than one incontinence pad per day and a MS type other than relapsing-remitting.
Atan et al. [19]	1999	Prospective cohort	4	15	Continued routine urological surveillance for infection and stones is mandatory in patients who undergo ileovesicostomy.
Lawrenson et al. [20]	2001	Case-control (database estimative)	4	NR	Patients with paraplegia or neural tube defects were found to have a substantially increased risk of renal failure compared with the general population.
Cameron et al. [21]	2012	Systematic review	NA	NA	12 articles dealing with UTIs in neuro-urological patients. Symptoms used to predict UTI yielded mixed results and urine dipstick testing had the same accuracy as microscopy.

LE, level of evidence according to the Oxford Centre for Evidence-Based Medicine (2011); NR, not clearly reported; NA, not applicable.

of calculi (kidney and/or ureter) was 1.5% at 1-year follow-up and 1.9% at 5 years, and was more frequent in patients with complete tetraplegia. IC was the most common method of bladder management among patients with paraplegia but became less common at later visits after injury.

Chen et al. [12] have evaluated risk factors for kidney stones in patients with SCI. It was estimated that ≤10 years after injury, 7% of patients with SCI would develop their first kidney stone. The risk was greatest during the first 3 months after SCI (31 cases per 1000 person-years).

Bartel et al. [13] retrospectively assessed the occurrence of bladder stones in patients with SCI. Bladder stones were identified more often in patients with suprapubic catheters (11%). The recurrence rate was 23%, and was most frequent in the transurethral catheter group (40%).

Zhang and Liao [14] investigated risk factors predicting UUT deterioration in patients with SCI. UUT abnormalities were present in 23 patients (65.7%) in a spontaneous voiding group, 10 patients (20%) in the IC group, 15 patients (78.9%) with indwelling urethral catheterisation, and seven patients (87.5%) with suprapubic Foley catheterisation ($P < 0.001$). When dividing bladder management method into two groups, catheter-free (spontaneous and intermittent voiding) and indwelling catheter (urethral and suprapubic catheterisation), there was UUT dysfunction in 33 patients (38.3%) and 22 patients (81.5%), respectively ($P < 0.001$).

Follow-up in Patients with Spinal Dysraphism

Capitanucci et al. [15] evaluated the long-term urological follow-up in children with occult spinal dysraphism. Urinary incontinence was treated mainly by IC and antimuscarinics. At long-term follow-up (2–14 years), socially acceptable continence was achieved in 78% (57 children). UUT deterioration occurred in 15% and renal failure in 7.5%.

Vainrib et al. [16] assessed urodynamic findings in adult patients with neurogenic bladder and myelomeningocele before and after augmentation enterocystoplasty. Most patients maintain low bladder pressures for >10 years. Close

long-term follow-up should be maintained as elevated detrusor pressures can still be seen after reconstruction.

Follow-up in Patients with MS

Ciancio et al. [17] studied the urodynamic pattern changes in MS. Overall, 12 (55%) of 22 patients had a change in their urodynamic patterns and/or compliance during a mean follow-up interval of 42 ± 45 months between the urodynamic studies. It was concluded that urodynamic evaluations should be repeated at regular intervals in symptomatic patients to optimise clinical management, and reduce complications.

Wiedemann et al. [18] also studied LUTS in MS patients during rehabilitation. LUTS were evaluated with voiding diary, post-void ultrasound, and an urodynamic examination. The mean (SD) duration of MS was 10.26 (10.09) years and mean duration of LUTS was 6.9 (7.75) years. Urodynamics (UDS) showed urinary tract dysfunction in 78 of 100 patients with MS with LUTS, including detrusor overactivity in seven, increased bladder sensation without detrusor overactivity in 21, detrusor–sphincter dyssynergia (DSD) in 26, detrusor hypocontractility in 12, detrusor acontractility in four and unclear diagnosis in eight patients.

Other Follow-up Studies in Neuro-urological Patients

Atan et al. [19] followed neuro-urological patients with complications of previous bladder management, who underwent ileovesicostomy. All were either poor candidates for or refused continent urinary diversion or bladder augmentation cystoplasty. Long-term complications were stomal stenosis in two patients, bladder and kidney stone formation in five, and symptomatic UTIs in three.

Lawrenson et al. [20] studied renal failure risk in neuro-urological patients. All patients registered in the General Practice Research Database (GPRD) between 1994 and 1997, and aged 10–69 years were included in the study. The prevalence of renal failure in the general population was ascertained, and compared with the prevalence in patients with MS, paraplegia and neural tube defects. The age-standardised prevalence of renal failure in the GPRD population aged 10–69 years was 14 per 10 000. The rate ratio of renal failure compared with the general population in each of the years 1994–1997 for neural tube defects ranged between 6.8 and 9.0 in males and 9.2–11.5 in females, for paraplegia 4.1–9.0 in males and 4.0–7.0 in females, and for MS 0.4–1.3 in males and 0.5–2.2 in females. Their conclusion was that those neuro-urological patients should be regularly screened to detect renal impairment before the development of chronic renal failure.

For UTI screening, Cameron et al. [21] published a systematic review, which identified 12 articles dealing with neuro-urological follow-up. Routine urine culture was unnecessary in healthy, asymptomatic individuals with normal urine analysis.

Discussion

Regarding follow-up of the neuro-urological patient, there is a lack of high-level evidence studies and guidelines are mainly based on expert opinions. In the guidelines on *Bladder Management of Adults with Spinal Cord Injury* [1], nine panel members and a further 34 contributors, 13 of them expert reviewers of relevant scientific organisations, have elaborated the guidelines, which are based on 107 publications. The recommendations for long-term care in the manual *Neuro-Urology and Spinal Cord Lesion*, produced by the working-group 'Urological Rehabilitation of Spinal Cord Injury Patients' are based on the consensus of eight neuro-urologists with expertise. In the recommendations in *A Proposed Guideline or the Urological Management of Patients with Spinal Cord Injury*, eight experts from the UK were involved.

The value of adequate urological long-term care is also reflected in an article by Osterthum et al. [22] from the Netherlands, in which the causes of death after SCI during patient rehabilitation and the first 5 years after discharged are reported. In the Netherlands, from 12% of persons with SCI, who had survived the acute hospital phase and died during the follow-up (mean follow-up 5.2 years), the main causes of death were cardiovascular and pulmonary disease, none of the patients died from renal failure. This is very much in contrast to reports from only 20 years ago, when renal failure was the most frequent cause of death in patients with SCI [20].

On the other hand, according to Cameron et al. [21], no definitive recommendations on follow-up strategies can be made in NLUTD after SCI, except for routine renal ultrasound. UDS are regarded as an important part of screening but the frequency is unclear.

Burki et al. [23] addressed the effects of the European Association of Urology (EAU) *Guidelines on Neuro-Urology* and the proposed *British Guidelines for the Urological Management of Patients with SCI* in the UK. These authors concluded that there was a continued lack of high-quality evidence to support an optimal long-term follow-up protocol. Additionally, there was a lack of evidence on clinical outcomes when these guidelines had been strictly followed.

Follow-up strategies are essential to the neuro-urological patients, as NLUTD is often unstable and the symptoms may vary considerably, even within a relatively short period of time. Despite of the fact that prospective studies on the follow-up of these patients are scarce, there are three main points to be discussed: (i) what should be included as general and/or specific investigations, (ii) what is the optimal time

schedule for controls, and (iii) who should be responsible for counselling the patients?

The follow-up of the neuro-urological patients comprises (A) General and (B) specific investigations. The following recommendations are mostly based on expert opinions, some of them published in relevant guidelines.

A. General Investigations

An interim history should address changes with respect to previous investigations, related to bladder emptying, continence, non-febrile or febrile UTIs, antibiotic treatment received, mode of defecation, sexual function, spasticity if present, and use of medication.

a) Clinical investigations should evaluate the physical status, including rectal investigation of the prostate and rectum (to exclude faecal impaction). The neuro-urological status should comprise the evaluation of spasticity, sensation in the sacral dermatomes S3–S5, anal inspection, sphincter tone, anal reflex, bulbocavernosus reflex, voluntary contraction of sphincter ani, and pelvic floor muscle. They should also comprise 'non-invasive' UDS, such as a bladder (catheterisation) diary, observation of voiding or uroflowmetry and post-void residual urine volume (PVR) observation (also as a prerequisite for further urodynamic investigation) (expert opinions).
b) Laboratory investigation must comprise urine status, leucocyte count, bacteria count, antibiogram when needed, blood investigation with erythrocyte sedimentation rate, blood count, C-reactive protein (CRP), creatinine, urea, uric acid, electrolytes, and PSA, if applicable. Normal serum creatinine does not exclude renal dysfunction in patients with SCI, due to their reduced muscle mass, instead isotope clearance examination should be performed or cystatin C evaluated. In long-term antimuscarinic treatment, liver function should be assessed (expert opinions).
c) Ultrasound investigation of the UUT and LUT should be evaluated, including PVR.

B. Specific Investigations

Special investigations should be performed for special indications, depending on type of the neurogenic bladder, risk factors, and therapy performed. They comprise invasive UDS (cystometry, pressure-flow-studies, VUDS), voiding and/or cystourethrography, especially in patients using IC, and endoscopy (restricted indications see below). For kidney morphology and function (see above), Intravenous urography (IVU) is rarely indicated nowadays for evaluation of renal pelvis and ureters.

Specific investigations should be performed by urologists with neuro-urological experience, aimed at specific patient groups.

The value of cystoscopy for traumatic SCI patients, managed with indwelling catheter, was recently investigated by El Masri et al. [7], and their conclusion was that cystourethroscopic surveillance in high-risk patients with indwelling catheter is essential to diagnose and manage complications at an early stage. However, it is important to recognise that findings detected with endoscopy did not show a significant difference in the symptomatic and in the asymptomatic group.

UDS are the only method to evaluate the pressure situation in the LUT during storage and emptying. The indication of which type of UDS should be performed, a simple cystometry, pressure-flow studies, or VUDS, are again dependent on previous findings and risk factors.

More comprehensive information is provided by VUDS, informing additionally about the radiological appearance of the bladder, bladder neck, and posterior urethra during filling and emptying. A urethrogram is indicated in male patients using IC, and should be performed from time to time routinely or when the patient complains about difficulties with catheterisation. To evaluate the renal pelvis and the ureters also nowadays an IVU may be indicated.

With cerebral diseases the risk for UUT damage is low. Therefore, e.g. in a stroke patient with overactive bladder symptoms, UDS is not necessary when voiding is without PVR. In suprasacral SCIs, invasive UDS, or preferably VUDS, should be performed regularly, at least during the first 3–5 years after the injury, as the change in compliance and pressure due to increasing DSD may be present before symptoms occur, and can then be diagnosed in time before possibly irreversible changes in the urinary tract have occurred. UDS are not essential for every patient with MS. However, despite there being no strong evidence to suggest that repeated examinations may change outcomes, UDS are particularly useful to evaluate the pattern of LUT dysfunction in patients with refractory symptoms, especially in those with failure of conservative urological management or risk of UUT deterioration (expert opinions).

Also sacral and subsacral lesions deserve regular controls, especially when the bladder is expressed by Valsalva or Crede, as these manoeuvres may create unphysiologically high intravesical pressure, causing vesico-uretero-renal reflux. But also a low-compliance bladder may develop over time despite an incompetent sphincter, a condition only detected by UDS.

Regular ultrasound assessment is advisable. It cannot substitute invasive UDS/VUDS, because at the time when ultrasound shows changes in the LUT and UUT these changes may already have caused damage to the LUT and UUT. This statement is based on clinical experience, as no comparative studies are available to document the level of evidence and the grade of recommendation. Also with sacral/subsacral lesions and documented neurogenic detrusor acontractility, a low

compliance bladder can occur over time, which again can only be diagnosed with invasive UDS.

For the time schedule for controls in the guidelines on *Bladder Management for Adults with Spinal Cord Injuries: A Clinical Practice Guideline for Health-Care Providers*, published in 2006 [1], the authors state that 'no studies have been done on the optimal frequency of follow-up evaluations', and this is also true for the following recommendations. Experts agree that the time schedule for controls and the amount of investigations to be done depend primarily on risk factors. Patients without a history of recurrent UTI based on the interim history, without risk factors in previous investigations, and without significant PVR, should perform self-control of urine (strip-test) routinely once a month or if UTI is suspected. This is the case when the GP or the urologist should be contacted. Annual ultrasound of kidney and bladder, including PVR, should be performed. In general, in patients with SCI, invasive UDS should be performed after initial rehabilitation yearly during the first 3 years, and thereafter every 2 and 3 years.

What Are the Risk Factors and How to Detect Them?

Amongst general risk factors, based on history and/or clinical/radiological findings, the German working group [35] mentions febrile UTI, recurrent UTI (more than two episodes per year), hypotensive crisis (related to autonomous dysreflexia), increased PVR on multiple measurements, increase or new occurrence of urinary incontinence and/or voiding problems, hydronephrosis (ultrasound), change of bladder morphology (trabeculations, pseudo-diverticulae), persistent abnormal laboratory findings (CRP, leucocytes, kidney function, as well as any indication for deterioration of kidney functions). If these risk factors are present, consultation with an experienced neuro-urologist or neuro-urological centre is regarded as essential.

Zhang and Liao [14], retrospectively analysing medical records and UUT images of 112 patients, found as predictors for UUT deterioration, lumbar–sacral SCI, chronic indwelling urethra and suprapubic catheterisation. However, there are patients with risk factors that may remain clinically silent over a longer period of time, which can only be detected by UDS/VUDS. The guidelines for urological care of patients with SCI edited by the German working group on urological rehabilitation of patients with SCI (2007) has mentioned as urodynamic risk factors for UUT deterioration, related to (VUDS), high pressures during the filling place, a low compliance of <20 mL/cmH_2O, a high leak-point pressure (LPP), prolonged detrusor contraction, and low reflex volume with high PVR. For high pressure during the voiding phase, a maximum detrusor pressure in men of >80 cmH_2O and in women of >60 cmH_2O were regarded as risk factors, as well as significant DSD, and high PVR (>100 mL or more than 30% of functional bladder capacity). For the pressures, most authors refer to the paper of Wang et al. [24]. This study was done in children with myelodysplasia, and in this group the crucial detrusor LPP was 40 cmH_2O: >40 cmH_2O deterioration of the UUT could be expected in 89%, if below in only 10%. However, this is a single-centre observation, it was never reproduced and it was only done in children. Surprisingly and strangely enough, there are no studies have been done to date in adults to correlate the detrusor storage and/or voiding pressures with UUT changes.

Table 2 Recommendations for follow-up, according to the EAU guidelines on Neuro-Urology [4]].

Recommendations	LE	Grade
In high-risk patients, the UUT should be assessed at least every six months	4	A
In high-risk patients, physical examination, and urine laboratory should take place every year	4	A
Any significant clinical changes should instigate further, specialized, investigation	4	A
Urodynamic investigation is a mandatory baseline diagnostic and in high-risk patients, should be done at regular intervals	3	A

LE, level of evidence according to the Oxford Centre for Evidence-Based Medicine (2011).

Other risk factors were prolonged detrusor contractions, autonomic dysreflexia, vesico-ureteric-renal reflux and influx into the male adnexa. However, these statements are obviously based on expert opinion and not on controlled studies. Autonomic dysreflexia is a medical emergency and is often related to urological, gastrointestinal or gynaecological problems, and manipulations. If there is a history of autonomic dysreflexia, urodynamic investigations should be done under continuous blood pressure and pulse monitoring and physicians must be aware of treatment cascade.

The Guidelines of the EAU on Neuro-Urology [4] recommend regular 'urochecks', whose intervals depend on the type of neurogenic lesion, as well as on the dysfunctional pattern. According to these guidelines, control intervals of >2 years are not recommended. Ultrasound of the urinary tract and PVR assessment should be performed if possible every 6 months, including a clinical investigation with blood and urine parameters once a year (Table 2) [4].

In the *A proposed guideline for the urological management of patients with spinal cord injury* [3], ongoing surveillance and the need for ultrasound controls of the UUT and PVR evaluation once a year are postulated.

Experts of a round-table on long-term care of patients with SCI during the first International Neuro-Urology Meeting in Zürich (2012) came to the conclusion that non-invasive UDS must be part of a routine 'urocheck', as only the results of these investigations allow the detection of risk-factors in time, before irreversible damage has occurred. In patients with MS

the same rules as for patients with SCI should be applied, once a high PVR and/or recurrent UTIs occur [5].

Basically the general investigations (see above) could be done by the general urologist or by a GP with a relevant interest in neuro-urological problems. However, if risk factors are present, the 'urocheck' should be performed by the neuro-urologist responsible at a neuro-urological centre.

When to Introduce IC?

Most studies report the beneficial results with IC; however, distinct indications can be drawn from the literature only indirectly. The indications for IC are: (i) inadequate detrusor contraction (too weak for balanced voiding or too strong creating a high pressure situation in the bladder during storage and/or voiding), (ii) unbalanced voiding due to functional outflow obstruction, and (iii) a PVR urine of ≈100 mL or >30% of functional bladder capacity, which are regarded as a risk factors. Although IC is mentioned in almost all guidelines and recommendations as the method of choice to empty the neurogenic bladder, the indications are not reported specifically and can only be extracted indirectly.

Conclusions

NLUTD is not a static condition, but follows its own natural history that can manifest in changes of the LUT and UUT, firstly functionally, later on morphologically. Such a development is promoted by risk-factors mostly based on high-pressure situations in the bladder during storage and/or voiding, some of them are recognisable from clinical symptoms, and others remain clinically silent over a long time, and can only be detected by (video-) urodynamic investigations. The time schedule of investigations, as well as the amount and type of investigation, is different in different neurological lesions. They depend on the dysfunctional pattern of the LUT and its risk profile. Regular and risk adapted controls ('urochecks') allow the detection of risk-factors in time before irreversible changes of the LUT and UUT have occurred.

The goal of a neuro-urological follow-up is the best possible preservation of UUT and LUT function in relation to the individual neurological disorder. With a risk- and patient-oriented lifelong regular urological care, an optimised quality of life and life-expectancy can be achieved, although there is a complete lack of high-evidence level studies on this topic.

Conflicts of Interest

H.M. reports other from Apogepha Germany, other from Astellas, Austria, other from Wellspect, Sweden, other from Montavit, Austria, outside the submitted work.

M.A. has nothing to disclose.

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Correspondence: Marcio Augusto Averbeck, c/o Dept. Urology, Mae de Deus Center Hospital, Rua Soledade, 569, Bairro Três Figueiras, Torre Beta – 9. Andar Sala 907, Porto Alegre 90470-340, Brazil.

e-mail: marcioaverbeck@gmail.com

Abbreviations: CRP, C-reactive protein; DSD, detrusor–sphincter dyssynergia; EAU, European Association of Urology; GPRD, General Practice Research Database; IC, intermittent catheterisation; LPP, leak-point pressure; (N)LUT(D), (neurogenic) lower urinary tract (dysfunction); MS, multiple sclerosis; PVR, post-void residual urine volume; SCI, spinal cord injury; UUT, upper urinary tract; (V)UDS, (video-) urodynamics.