

The Standardization of Terminology in Neurogenic Lower Urinary Tract Dysfunction

With Suggestions for Diagnostic Procedures

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1. INTRODUCTION

This report has been produced at the request of the International Continence Society. It was approved at the twenty-eighth annual meeting of the Society in Jerusalem.

The terminology used in neurogenic lower urinary tract dysfunction developed over the years, defined by neurologists, neurological, and urological surgeons. Because of the particular intents of each specialist, confusion exists on the various terminologies used and on their definitions. The International Continence Society did not define in detail the procedures and conditions in neurogenic lower urinary tract

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dysfunction. During our discussions the need for standardization of this terminology became obvious.

This report follows the earlier standardization report for lower urinary tract dysfunction [Abrams et al., 1988, 1990] and is adapted to the specific group of patients with neurogenic lower urinary tract dysfunction. Terms defined in the earlier report are marked (*) and their definitions not repeated here. New or adapted definitions follow *the terms in italics*.

Any pertinent texts repeated from the earlier report are marked in the margin.

If they are not repeated completely, this is marked by the term (abbreviated).

Recently, the International Continence Society published a dedicated standardization report on pressure-flow studies [Griffiths et al., 1997]. This adapts and extends the earlier report with respect to pressure and flow plots and the analysis of the results and provides a provisional standard. Some new definitions are added, some existing ones changed, and some others no longer used. (Changed) definitions from this second report are marked differently (+).

Two more reports from the International Continence Society are in preparation and bear a relationship to the present report: A general report on Good Urodynamic Practice [Schäfer et al.] and a dedicated report on Standardization of Ambulatory Urodynamic Monitoring [Van Waalwijk et al.]. This document is intended to be complementary to the mentioned reports and to be consistent in particular with the recommendations in the report of Schäfer et al.

Neurogenic lower urinary tract dysfunction is lower urinary tract dysfunction due to disturbance of the neurological control mechanisms. Neurogenic lower urinary tract dysfunction thus can be diagnosed in presence of neurological pathology only.

2. CLINICAL ASSESSMENT

Before any functional investigation is planned, a basic general and specific diagnosis should be performed. In the present context of neurogenic lower urinary tract dysfunction, part of this diagnosis is specific for neurogenic pathology and its possible sequelae. The clinical assessment of patients with neurogenic lower urinary tract dysfunction includes and extends that for other lower urinary tract dysfunction.

The latter should consist of a detailed history, a frequency/volume chart and a physical examination. In urinary incontinence, leakage should be demonstrated objectively. These data are indispensable for reliable interpretation of the urodynamic results in neurogenic lower urinary tract dysfunction.

2.1 History

2.1.1 General history

The general history should include questions relevant to neurological and congenital abnormalities as well as information on previous urinary infections and relevant surgery. Information must be obtained on medication with known or possible effects on the lower urinary tract. The general history should also include the assessment of menstrual, sexual, and bowel function, and obstetric history.

Symptoms of any metabolic disorder or neurological disease that may induce neurogenic lower urinary tract dysfunction must be checked particularly. Presence of

spasticity or autonomic dysreflexia must be noted. A list of items of particular importance is

- Neurological complaints
- Congenital anomalies with possible neurological impact
- Metabolic disorders with possible neurological impact
- Preceding therapy, including surgical interventions
- Present medication
- Continence/incontinence (see urinary history)
- Bladder sensation (see urinary history)
- Mode and type of voiding (see urinary history)
- Infections of the lower urinary tract
- Defecation, including possible faecal incontinence (see defecation history)
- Sexual function (see sexual history)

2.1.2 Specific history

2.1.2.1 Urinary history. The urinary history must consist of symptoms related to both the storage and the evacuation functions of the lower urinary tract. Specific symptoms and data must be assessed in neurogenic lower urinary tract dysfunction and if appropriate be compared with the patients' condition before the neurogenic lower urinary tract dysfunction developed.

Specify:

- a) Urinary incontinence
 - Predictability of the occurrence of incontinence
 - Type of incontinence: Urge incontinence*, stress incontinence*, other incontinence
 - Position or condition when incontinence occurs (supine/sitting/standing/moving/bedwetting only)
 - Control of the incontinence: Medication, pads, external appliances, penile clamp, urethral plug, pessary, catheterisation
 - Extent of the incontinence: Pad number or weight or estimated volume per 24 hour period, frequency/volume chart*
- b) Bladder sensation*:
 - Absent*
 - Specific bladder sensation (desire to void*, urgency*, pain*)
 - General sensation related to bladder filling (abdominal fullness, vegetative symptoms, spasticity)
- bb) If specific bladder sensation exists:
 - Normal*, hypersensitive*, or hyposensitive*
 - Can urgency be suppressed?
 - If yes, as effective as before the neurogenic condition?
- bbb) If the patient has normal bladder sensation:
 - Timing and duration of the sensation
 - Ability to initiate voiding voluntarily
 - Need for abdominal straining or other triggering to initiate or sustain voiding

- c) Mode and type of voiding:
- Voiding position (standing, sitting, supine)
 - Continuous* or intermittent flow*
 - Residual urine*
 - Initiation of voiding:
 - Voluntary voiding
 - Reflex voiding*: spontaneous or triggered (state type and area of triggering). Remark: Some patients with uncontrollable reflex voiding may use a condom urinal and a urine bag
 - Voiding by increased intravesical pressure (state mode of pressure increase: abdominal strain or Credé). Remark: Credé is contraindicated in children; also in adults when pressure exceeds 100 cm H₂O
 - Passive voiding by decreased outlet resistance (state mode: removal of urethral and/or vaginal appliances, sphincterotomy, TUR bladder neck, artificial sphincter)
 - Sacral root electrostimulation
- c1) If the patient has an artificial sphincter:
- Implant date and date(s) of revision surgery
 - Micturition frequency
 - Cuff pressure
 - Number of pump strokes
 - Cuff closure time
 - Continence or stress incontinence with closed sphincter
- c2) If the voiding is induced by sacral root electrical stimulation:
- Implant date and date(s) of revision surgery
 - Location of electrodes (roots used)
 - Stimulation parameters
 - Micturition frequency
 - Duration of voiding stimulation
 - “Double voiding” stimulation
- c3) If the patients empties the bladder by catheterisation, residual urine is assessed to check also the effectiveness of the catheterisation
- c31) *Intermittent catheterisation*: Emptying of the bladder by catheter, mostly at regular intervals. The catheter is removed after the bladder is empty. The procedure may be *sterile intermittent catheterisation*: Use of sterile components or *clean intermittent catheterisation*: At least one component is not sterile. *Intermittent self-catheterisation* is performed by the patient.
- Type, size, and material of catheter (conventional, hydrophylic)
 - Use of lubricating jelly (intra-urethral or on catheter only) or soaking (sterile saline, tap water)
 - Disinfection of meatus
- c32) An *indwelling catheter* is permanently introduced into the bladder. An external urine collecting device is used.
- Transurethral or suprapubic approach
 - Type, size, and material of catheter

- Type of collecting device and associated materials (anti-reflux valves)
 - Interval between changes of collecting device
- d) *Urinary diary* (Frequency/volume chart*)

The frequency/volume chart is a specific urodynamic investigation recording fluid intake and urine output per 24 hour period. The chart gives objective information on the number of voidings, the distribution of voidings between daytime and night-time and each voided volume. The chart can also be used to record episodes of urgency and leakage and the number of incontinence pads used.

The urinary diary is also useful in patients who perform intermittent catheterisation. A reliable urinary diary cannot be taken in less than 2–3 days. The urinary diary permits the assessment of voiding data under normal physiological conditions.

- Time and volume for each voiding or catheterisation
- Total volume over the period of the recording or 24 hour volume
- Diurnal variation of volumes
- *Functional bladder capacity*: average voided volume
- *Voiding interval*: average time between daytime voidings
- *Continence interval*: average time between incontinence episodes or between last voiding and incontinence (assessed only during daytime)
- The fluid intake may also be recorded

Only for patients who use catheterisation it is also feasible to assess:

- Residual urine
- *Total bladder capacity*: Sum of functional bladder capacity and residual urine

2.1.2.2 Defecation history. Patients with neurogenic lower urinary tract dysfunction may suffer from a related neurogenic condition of the lower gastro-intestinal tract. The defecation history also must address symptoms related to the storage and the evacuation functions and specific symptoms and data must be compared with the patients' condition before the neurogenic dysfunction developed.

Specify:

- a) Faecal incontinence:
- Extent (complete, spotting, diarrhoea, flatulence)
 - Pads use (type and number)
 - Anal tampons (number)
- b) Rectal sensation:
- Filling sensation
 - Differentiation between stool, liquid stool and flatus
 - Sensation of passage
- c) Mode and type of defecation:
- Toilet use or in bed
 - Frequency of defecation
 - Duration of defecation
 - Use of oral or rectal laxatives
 - Interval between laxatives and defecation
 - Use of enema (frequency, amount used)

- Antegrade continence enema (date of surgery, date(s) of revision, frequency of stomal dilation, frequency of washout)
- Initiation of defecation:
 - Voluntary or spontaneous
 - After digital stimulation
 - Mechanical emptying (patient or caregiver)
 - Sacral root electrical stimulation
- c1) If the defecation is induced by sacral root electrical stimulation:
 - Implant date and date(s) of revision surgery
 - Location of electrodes (roots used)
 - Stimulation parameters
 - Continuous or interrupted stimulation (interval)
 - Combination with other treatment (laxatives or rectal mucosal stimulation)

2.1.2.3 *Sexual history.* The sexual function may also be impaired because of the neurogenic condition.

Specify:

Males:

- a) Sensation in genital area and for sexual functions (increased/normal/reduced/absent)
- b) Erection:
 - Spontaneous or inducible by psychogenic stimuli
 - Mechanical or medical initiation (state method or drug)
 - Sacral root electrical stimulation
- b1) If the erection is induced by sacral root electrical stimulation:
 - Implant date and date(s) of revision surgery
 - Location of electrodes (roots used)
 - Stimulation parameters
 - Leg clonus (absent/present)
 - If erection is insufficient: Use of supportive treatment
- c) Intercourse (erection sufficient or extra mechanical stimulation)
- c1) If the erection is insufficient state tumescence, rigidity, duration
- d) If the patient has a penile implant:
 - Implant date and date(s) of revision surgery
 - Type of prosthesis
 - Result of implantation
 - Frequency of use
- e) Ejaculation:
 - Natural (normal, dribbling, semen quality and appearance)
 - Artificial:
 - Vibrostimulation, electro-ejaculation, intrathecal drugs (frequency, results)
 - Semen analysis (most recent, result)

Females:

- a) Sensation in genital area and for sexual functions (increased/normal/reduced/absent)
- b) Arousal or orgasm inducible (psychogenic or mechanical stimuli)

2.2 Physical examination

2.2.1 General physical examination

Attention should be paid to the patient's physical and possible mental handicaps with respect to the planned investigation. Impaired mobility, particularly in the hips, or extreme spasticity may lead to problems in patient positioning in the urodynamics laboratory. Patients with very high neurological lesions may suffer from a significant drop in blood pressure when moved in a sitting or standing position. Subjective indications of bladder filling sensations may be impossible in retarded patients.

2.2.2 Neurourological status

Specify:

- Sensation S₂–S₅ (both sides): Presence (increased/normal/reduced/absent), type (sharp/blunt), afflicted segments
- Reflexes: Bulbocavernous reflex, perianal reflex, knee and ankle reflexes, plantar responses {Babinski} (increased/normal/reduced/absent)
- Anal sphincter tone (increased/normal/reduced/absent)
- Anal sphincter and pelvic floor voluntary contractions (increased/normal/reduced/absent)
- Prostate palpation
- Descensus of pelvic organs

2.2.3 Laboratory tests

- Urinalysis (infection treatment, if indicated and possible, before further intervention)
- Blood laboratory, if necessary
- Free flowmetry and assessment of residual urine (mostly sonographic; by catheter in patients catheterising or immediately preceding a urodynamic investigation). Because of natural variations, multiple estimations are necessary (at least 2–3)
- Quantification of urine loss* by pad testing, if appropriate
- Imaging:
 - Sonography: Kidneys (size, diameter of parenchyma, pelvis, calyces)
Ureter (dilation)
Bladder wall (diameter, outline, trabeculation, diverticulae or pseudodiverticulae)
 - X-ray: Cystography, excretion urography, urethrography, clearance studies, if necessary.
Apart from the data in sonography, attention must be paid to urinary stones, spinal anomalies, reflux, bladder neck condition, and urethral anomalies.
 - MRI: Accordingly

3. INVESTIGATIONS

In patients with neurogenic lower urinary tract dysfunction, and particularly when detrusor hyperreflexia* might be present, the 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 [Schäfer et al.].

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

In many patients with neurogenic lower urinary tract dysfunction, assessment of maximum (anaesthetic) bladder capacity* may be useful. The rectal ampulla should be empty of stool before the start of the investigation. Medication by drugs that influence the lower urinary tract function should be abandoned at least 48 hours before the investigation (if feasible) or otherwise be taken into account for the interpretation of the data.

3.1 Methods

In neurogenic lower urinary tract dysfunction a combination of urodynamic investigations is mostly warranted. Some comments on the use of a single investigation are listed (see also Section 4). Urodynamic investigation should be performed only when the patient's free flowmetry and residual data are available (see Section 2.2.3) if the patient's condition permits these tests.

3.1.1 Measurement of urinary flow*

Care must be taken in judging 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 this inappropriate position and by any constructions to divert the flow.

3.1.2 Cystometry*

Cystometry is used to assess detrusor activity, sensation, capacity, and compliance. As an isolated investigation this is probably only useful for follow-up studies of treatment.

3.1.3 Leak point pressure measurement [McGuire et al., 1996]

There are two kinds of leak point pressure measurement. The detrusor leak point pressure is a static test and the abdominal leak point pressure is a dynamic test. The pressure values at leakage should be read exactly at the moment of leakage.

The *detrusor leak point pressure* is the lowest value of the detrusor pressure* at which leakage is observed in the absence of abdominal strain or detrusor contraction.

Detrusor leak point pressure measurement assesses the storage function and detrusor compliance, in particular in patients with neurogenic lower urinary tract dysfunction, with low compliance bladder (see below) or with reflex voiding. High detrusor leak point pressure puts these patients at risk for upper urinary tract deterioration or might cause secondary damage to the bladder. A detrusor leak point pressure above 40 cm H₂O appears hazardous [McGuire et al., 1996].

The *abdominal leak point pressure* is the lowest value of the intentionally increased intravesical pressure* that provokes urinary leakage in the absence of a detrusor contraction. The abdominal pressure increase can be induced by coughing (*cough leak point pressure*) or by Valsalva (*Valsalva leak point pressure*) with in-

creasing amplitude. Multiple estimations at a fixed bladder volume (200–300 ml in adults) are necessary.

For patients with stress incontinence, the abdominal leak point pressure measurement gives an impression of the severity (slight or severe) or the nature (anatomical or intrinsic sphincter deficiency) of incontinence.

With the assumption that the intravesical pressure in abdominal leak point pressure is caused only by the abdominal pressure, vaginal pressure or rectal pressure may also be used to record the intravesical pressure. This will obviate the need for intravesical catheterisation.

3.1.4 Bladder pressure measurements during micturition* and pressure-flow relationships*

Most types of obstructions caused by neurogenic lower urinary tract dysfunction are due to urethral overactivity* (detrusor/urethral dyssynergia*, detrusor-{external}-sphincter dyssynergia*, and detrusor/bladder neck dyssynergia*). This urethral overactivity will increase the detrusor voiding pressure above the level that is needed to overcome the urethral resistance⁺ given by the urethra's inherent mechanical and anatomical properties. Pressure-flow analysis mostly assesses the amount of mechanical obstruction* caused by the latter properties and has limited value in patients with neurogenic lower urinary tract dysfunction.

3.1.5 Electromyography* (often combined with cystometry/uroflowmetry)

Depending on the location of the electrodes, the electromyogram records the function of

- External urethral and/or anal sphincter
- Striated pelvic floor muscles

Owing to possible artefacts caused by other equipment used in a urodynamic investigation, its interpretation may be difficult.

3.1.6 Urethral pressure measurement*

Urethral pressure measurement has a limited place in the diagnosis of neurogenic lower urinary tract dysfunction. The following techniques are available:

- Resting urethral pressure profile*
- Stress urethral pressure profile*
- Intermittent catheter withdrawal (to cope with massive reflex contractions)
- *Continuous urethral pressure measurement*: the catheter sensor or opening is placed at about the point of maximum urethral closure pressure* and left there over time. This records time variations of urethral pressure and responses to various conditions of the lower urinary tract

3.1.7 Video urodynamics

Definition: Combination of lower urinary tract imaging during filling and voiding with urodynamic measurements.

3.1.8 Ambulatory urodynamics

An *ambulatory urodynamic investigation* is defined as any functional investigation of the urinary tract utilizing predominantly natural filling of the urinary tract and reproducing normal subject activity [Van Waalwijk et al.]. The recording of an ambulatory urodynamic investigation is comparable to Holter EKG and the patient is more or less in a situation of daily life. More detailed information on standardization of ambulatory urodynamics is found in the specific report [Van Waalwijk et al., submitted].

3.1.9 Provocative tests during urodynamics

- Coughing, triggering, anal stretch
- Ice water test
- Carbachol test
- Acute drug tests

3.1.10 Maximum (anaesthetic) bladder capacity measurement

The volume measured after filling during a deep general or spinal/epidural anaesthetic.

3.1.11 Specific uro-neurophysiological tests

- Electromyography (in a neurophysiological setting)
- Nerve conduction studies*
- Reflex latency measurements*
- Evoked responses*
- Sensory testing*

3.2 Measurement technique

3.2.1 Measurement of urinary flow

Specify:

- 0) Type of voiding:
 - Spontaneous voiding: Voluntary or reflex voiding
 - Triggered voiding or sacral root electrostimulation:
Type of triggering
 - a) Voided volume
 - b) Patient environment and position (supine, sitting or standing)
 - c) Filling:
 - i) By diuresis (spontaneous or forced; specify regimen)
 - ii) By catheter (transurethral or suprapubic)
 - d) Type of fluid
- Technique:
- a) Measuring equipment
 - b) Solitary procedure or combined with other measurements

3.2.2 Cystometry

All systems are zeroed at atmospheric pressure. For external transducers the reference point is the level of the superior edge of the symphysis pubis. For catheter mounted transducers the reference point is the transducer itself.

If a different type of catheter is used in follow-up cystometries the findings in Rossier and Fam [1986] may be of interest.

Specify:

a) Access (transurethral or percutaneous)

b) Fluid medium (liquid or gas)

Gas filling should not be used in patients with neurogenic lower urinary tract dysfunction.

State type and concentration of liquid used (for example, contrast medium, isotonic saline).

c) Temperature of fluid (state in degree Celsius)

In neurogenic lower urinary tract dysfunction a body-warm filling medium is advised.

d) Position of patient (e.g., supine, sitting, or standing)

Offer the patient the individually most comfortable position, particularly when voiding.

e) Filling may be by diuresis or catheter. Filling by catheter may be continuous or incremental; the precise filling rate should be stated

When the incremental method is used the volume increment should be stated.

For general discussion, the following terms for the range of filling may be used:

i) Up to 10 ml per minute is slow fill cystometry (“physiological” filling)

ii) 10–100 ml per minute is medium fill cystometry

iii) Over 100 ml per minute is rapid fill cystometry

A physiological filling rate or alternatively a maximum filling rate of 20 ml per minute is advised in neurogenic lower urinary tract dysfunction to prevent provocation of detrusor hyperreflexia or other sequelae of faster filling. From ambulatory urodynamics data the impression arises that the mentioned filling rates should be reconsidered [Klevmark, 1997].

Technique:

a) Fluid-filled catheter—specify number of catheters, single or multiple lumens, type of catheter (manufacturer), size of catheter

b) Catheter tip transducer—list specifications

c) Other catheters—list specifications

d) Measuring equipment

3.2.3 Leak point pressure measurement

Specify:

a) Location and access of pressure sensor (intravesical—transurethral or percutaneous, vaginal, or rectal)

b) Position of patient (for instance supine, sitting, or standing)

c) Bladder filling by diuresis or catheter (state type of liquid)

d) Bladder volume during test, also in relation to maximum cystometric capacity*

Technique:

- a) Mode of leak detection (observation, alarm nappy, meatal or urethral conductance measurement, or other)
- b) Catheters—list specifications, type (manufacturer) and size
- c) Measuring equipment for pressure and, if applicable, for leak detection

3.2.4 Bladder pressure measurements during micturition and pressure-flow relationships

The specifications of patient position, access for pressure measurement, catheter type, and measuring equipment are as for cystometry (see Section 3.2.2).

If urethral pressure measurements during voiding* are performed, the specifications are according to those in urethral pressure measurement (see Section 3.2.6).

If other assessments of the relation between pressure and flow are used (for example stop test, urethral occlusion, condom urinal occlusion) the specifications should be equivalent, according to the technique used.

3.2.5 Electromyography

The extensive specifications in the earlier report are appropriate in a neurophysiological setting. They are condensed here for practical use during urodynamics.

Specify:

- a) EMG (solitary procedure, part of urodynamic or other electrophysiological investigation)
- b) Patient position (supine, standing, sitting or other)
- c) Electrode placement (surface electrodes or intramuscular electrodes)
 - i) sampling site (abbreviated)
 - ii) recording electrode: location (abbreviated)
 - iii) reference electrode position

Note: Ensure that there is no electrical interference with any other machines, for example, X-ray apparatus.

Technique:

- a) Electrodes:
 - i) Needle electrodes: type, size, material (abbreviated)
The same holds for other types of intramuscular electrodes (for example enamel wire)
 - ii) Surface electrodes: type, size, material, fixation, conducting medium (abbreviated)
- b) Amplifier (make and specifications)
- c) Signal processing (data: raw, averaged, integrated or other)
- d) Display equipment (abbreviated)
- e) Storage (abbreviated)
- f) Hard copy production (abbreviated)

3.2.6 Urethral pressure measurement

Because of its limited place in neurogenic lower urinary tract dysfunction, the reader is referred to the earlier standardization report [Abrams et al., 1988, 1990] for the specifications.

3.2.7 *Video urodynamics*

Specify imaging system (fluoroscopy, ultrasound). Further specifications according to the type of urodynamic study.

3.2.8 *Ambulatory urodynamics*

Specifications according to the type of urodynamic study.

3.2.9 *Provocative tests during urodynamics*

Specify type of test, type of trigger, or drug used. Further specifications according to type of urodynamic study.

3.2.10 *Maximum (anaesthetic) bladder capacity measurement*

Specify fluid temperature, filling pressure, filling time, type of anaesthesia, anaesthetic agent, and dosage.

3.2.11 *Specific uro-neurophysiological tests*

Electromyography (see Section 3.2.5)

Nerve conduction studies, reflex latency measurements, evoked responses

Specify:

- a) Type of investigation (abbreviated)
 - b) Is the study a solitary procedure or part of a urodynamic or neurophysiological investigation?
 - c) Patient position and environmental temperature, noise level and illumination
 - d) Electrode placement (abbreviated)
- Technique:
- a) Electrodes (abbreviated)
 - b) Stimulator (abbreviated)
 - c) Amplifier (abbreviated)
 - d) Averager (abbreviated)
 - e) Display equipment (abbreviated)
 - f) Storage (abbreviated)
 - g) Hard copy production (abbreviated)

Sensory testing

Specify:

- a) Patient position (supine, sitting, standing, and other)
- b) Bladder volume at time of testing
- c) Site of applied stimulus (intravesical and intraurethral)
- d) Number of times the stimulus was applied and the response recorded.
Define the sensation recorded, for example the first sensation or the sensation of pulsing
- e) Type of applied stimulus (abbreviated)

3.3 Data

3.3.1 Measurement of urinary flow

- Voided volume*
- Maximum flow rate*
- Flow time*
- Average flow rate*
- Time to maximum flow*
- Flow pattern, includes the statement of continuous or intermittent voiding
- Voiding time*, when the voiding is intermittent
- *Hesitancy*: The occurrence of significant delay between the patient's voluntary initiation of micturition as signalled for example by pushing the marker button on the flow meter and the actual start of flow (note the flow delay⁺)

3.3.2 Cystometry

- Intravesical pressure
- Abdominal pressure
- Detrusor pressure
- Infused volumes at:
 - First desire to void* or other sensation of filling
 - Normal desire to void* or other sensation that indicates the need for a toilet visit
 - *Reflex volume*: Starting of first hyperreflexive detrusor contraction
 - Urgency
 - Pain (specify)
 - Maximum cystometric capacity (in patients with abolition of sensations, this is defined as the volume at which the investigator decides to stop filling)
 - Autonomic dysreflexia (specify)
- Compliance* $\{\Delta V/\Delta p_{det}\}$ (ml/cm H₂O) is mostly measured between (specify):
 - Reference value: Detrusor pressure at empty bladder (start of filling)
 - Measurement value: The (passive) detrusor pressure:
 - At maximum cystometric capacity in patients with existing sensation and without urine loss
 - At the start of the detrusor contraction leading to the first significant incontinence in patients with failing sensation or significant incontinence

➡ When a different volume range is used this should be specified in particular

A problem in the calculation of the compliance occurs when Δp_{det} is negative or zero: the defined calculation then gives a negative or infinite compliance. The first is physically impossible, the last gives little information. *In the compliance calculation a minimum value of 1 cm H₂O is used for Δp_{det} .* This means that the maximal possible value of the compliance will be equal to the volume range over which the compliance is calculated.
- *Break volume*: the bladder volume after which a sudden significant decrease of compliance is observed during the remainder of the filling phase (mind the distinction between passive detrusor pressure and detrusor contraction). It is yet unclear whether this observation is consistent in patients with neurogenic lower urinary tract dysfunction with or without detrusor hyperreflexia. When true, this might indicate that the detrusor is in a different state after the break volume

3.3.3 Leak point pressure measurement

- Minimum of measured pressure for first observation of leakage

3.3.4 Bladder pressure measurements during micturition and pressure-flow relationships

- Opening time* (note the flow delay)
- Opening pressure* (note the flow delay)
- Maximum pressure*
- Pressure at maximum flow⁺ (note the flow delay)
- Closing pressure⁺ (note the flow delay)
- Minimum voiding pressure⁺ (note the flow delay)

All pressure values will be estimated for intravesical, abdominal and detrusor pressure separately. They will not only differ in amplitude, but often also in timing. The detrusor pressure is generally the most important one. The maximum pressure values may be attained at a moment where the flow rate is zero [Griffiths et al., 1997].

3.3.5 Electromyography

- Recruitment patterns,* particularly in relation to specific stimuli (bladder filling, hyperreflexive contractions, onset of voiding, coughing, Valsalva, etc.)
- If individual motor unit action potentials are recorded: duration (msec) and amplitude (mV) of spontaneous activity, fibrillations, positive sharp waves, and complex repetitive discharges. Complexity and polyphasicity (descriptive or number)

3.3.6 Urethral pressure measurement

One parameter describing the contribution of the urethra to continence is the functional profile length*, the length of the urethra over which the urethral pressure exceeds intravesical pressure.

The functional profile length should reflect the length of the urethra that contributes to the prevention of leakage. In the female, this concept is straightforward, but in the male, the length of the bulbous and penile urethra will often add significantly to the functional profile length. The infra-sphincteric part of the urethra however contributes little, if any, to continence. The functional profile length in men thus is much greater than in women, without the associated implication that this greater length indeed is functional in maintaining continence. This functional part of the urethra probably extends down from the bladder to the junction from sphincteric to bulbous urethra, but this junction is often difficult to detect on the curve.

The contribution of the bulbous and penile urethra also show a large variance between patients and between several assessments in the same man. Therefore a third urethral length parameter is used, the *urethral continence zone*: the length of the urethra between the bladder neck and the point of maximum urethral pressure [Gleason et al., 1974] (Fig. 1).

- Resting urethral pressure profile:
 - Maximum urethral pressure*
 - Maximum urethral closure pressure

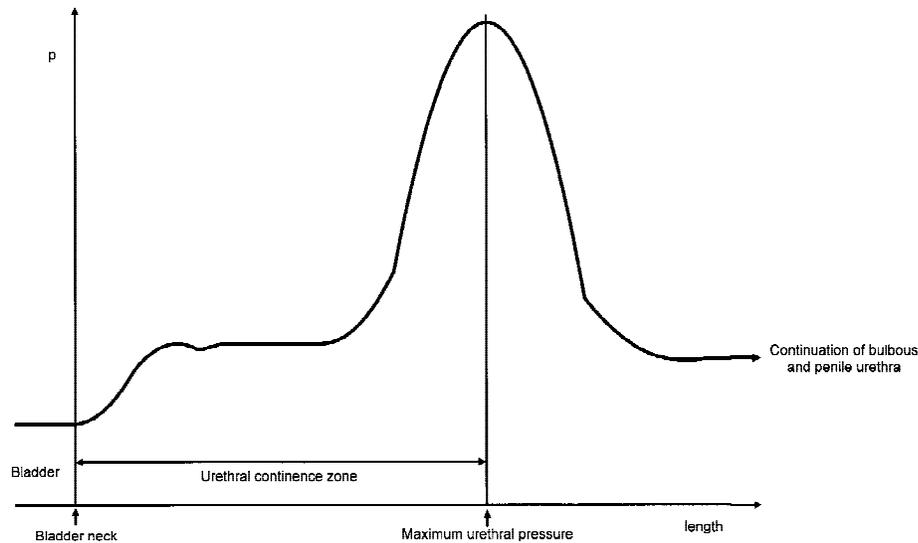


Fig. 1. Schematic measurement of urethral continence zone in men.

- Functional profile length (not mandatory in men)
- Urethral continence zone (not mandatory in women)
- Stress urethral pressure profile: above parameters and
 - Pressure “transmission” ratio*
- Intermittent withdrawal: above parameters and
 - Relaxing time before measurement is read
- Continuous urethral pressure measurement. This study is probably best represented by the measured curve. Urethral pressure variations in relation to specific stimuli (bladder filling, hyperreflexive contractions, onset of voiding, coughing, Valsalva, etc.) may be described separately

3.3.7 Video urodynamics

- According to type of urodynamic study
- Morphology:
 - Configuration and contour of the bladder during filling and voiding
 - Reflux, occurrence, and timing:
 - Into the upper urinary tract
 - Into the adnexa (for instance the prostate, the ejaculatory duct)
 - Bladder neck during filling and voiding phases
- Configuration of proximal urethra during filling and voiding, urethral kinking
- Bladder or urethral descensus

3.3.8 Ambulatory urodynamics

According to type of urodynamic study

3.3.9 Provocative tests during urodynamics

Response of the lower urinary tract function to the provocation. Compare with situation without provocation

3.3.10 Maximum (anaesthetic) bladder capacity measurement

Anatomical maximum volume that bladder will accommodate

3.3.11 Specific uro-neurophysiological tests

- Electromyography (see Section 3.3.5)
- Nerve conduction studies:
 - Latency time* (abbreviated)
 - Response amplitude* (abbreviated)
- Reflex latency measurement:
 - Response time* (abbreviated)
- Evoked responses:
 - Single or multiphasic response*
 - Onset of response* (abbreviated)
 - Latency to onset* (abbreviated)
 - Latency to peaks* (abbreviated)
 - The amplitude of the responses is measured in μV
- Sensory testing:
 - Sensory threshold* (abbreviated)

3.4 Typical manifestations of neurogenic lower urinary tract dysfunction

3.4.1 Filling phase

- Hyposensitivity or hypersensitivity
- Vegetative sensations for example goose flesh, sweating, headache, and blood pressure increase (particularly in patients with autonomic dysreflexia)
- *Low compliance*: Compliance value lower than 20 ml/cm H₂O
 - Cause: Neural or muscular (described before as hypertonic bladder)
- *High volume bladder*: A bladder that can be filled to far over functional bladder capacity in non-anaesthetised condition without significant increase in pressure (described before as hypotonic bladder). The use of the terms excessive or very high compliance to describe this situation is discouraged, as a high value of compliance will also be measured at lower volumes when only a slight increase in pressure occurs during filling
 - Cause: Neural or muscular
- Detrusor hyperreflexia, spontaneous or provoked; classified according to maximal detrusor pressure as *low-pressure hyperreflexia* or *high-pressure hyperreflexia*. Because of its clinical implications, as a practical guideline a value of 40 cm H₂O is proposed as cut-off value between low-pressure and high-pressure hyperreflexia [McGuire et al., 1996]
- *Sphincter areflexia*: No evidence of reflex sphincter contraction during filling, particularly at higher volumes, or during physical stress

3.4.2 Voiding phase

- Detrusor areflexia*
- *External sphincter hyperreflexia*: involuntary activity (for example, intermittently) of external sphincter during voiding other than detrusor sphincter dyssynergia
- Detrusor sphincter dyssynergia
- Detrusor bladder neck dyssynergia

4. CLINICAL VALUE AND CLASSIFICATION OF URODYNAMIC INVESTIGATION

Urodynamic investigation is needed for accurate evaluation of all patients with neurogenic lower urinary tract dysfunction. When effected in a standardised manner, it produces standardised and reproducible results (cf. [Schäfer et al.]). After the evaluation, its results must be summarised and evaluated:

1. Neurological background (type/duration of neurological disease or lesion) and characteristics of uro-neurophysiological tests
2. Characteristics of filling function
3. Characteristics of voiding function

In the conclusive evaluation the condition of the upper urinary tract and the incontinence care in incontinent patients must also be taken into account. Core investigation of patients with neurogenic lower urinary tract dysfunction will include:

1. History
2. Urine culture
3. Flow rate and post-void residual (multiple estimations)
4. Filling and voiding cystometry

Not all urodynamic procedures are equally important in the diagnosis of patients with neurogenic lower urinary tract dysfunction. The following list is an indication of the place of each procedure in these patients.

- 0: Urinary diary: Semi-objective quantification of the physiological lower urinary tract function. Advisable.
- 1: Free uroflowmetry and assessment of residual urine: First impression of voiding function. Mandatory before any invasive urodynamics is planned.
- 2: Cystometry. The only method to quantify filling function. Limited significance as a solitary procedure. Powerful when combined with bladder pressure measurement during micturition and even more in video urodynamics.
Necessary to document the status of the lower urinary tract function during the filling phase.
- 3: Leak point pressure measurement. Detrusor leak point pressure: Specific investigation if high pressures during the filling phase might endanger the upper urinary tract or lead to secondary bladder damage. Abdominal leak point pressure: Less important in neurogenic lower urinary tract dysfunction. Useful for patients with stress incontinence.
- 4: Bladder pressure measurements during voiding and pressure-flow relationships. Pressure measurements reflect the co-ordination between detrusor and urethra or pelvic floor during the voiding phase. Even more powerful in combination with cystometry and with video urodynamics. Necessary to document the status of the lower urinary tract function during the voiding phase.

Pressure-flow analysis is aimed at assessing the passive urethral resistance relation⁺ and as such of less importance in neurogenic lower urinary tract dysfunction.

- 5: Urethral pressure measurement. Limited applicability in neurogenic lower urinary tract dysfunction.
- 6: Electromyography: Vulnerable to artefacts when performed during a urodynamic investigation. Useful as a gross indication of the patient's ability to control the pelvic floor. When more detailed analysis is needed, it should be performed as part of a uro-neurophysiological investigation.
- 7: Video urodynamics: When combined with cystometry and pressure measurement during micturition probably the most comprehensive investigation to document the lower urinary tract function and morphology. In this combination the first choice of invasive investigations.
- 8: Ambulatory urodynamics: Should be considered when office urodynamics do not reproduce the patient's symptoms and complaints. May replace office (not video) urodynamics in future when all parameters from office urodynamics are available in ambulatory urodynamics too.
- 9: Specific uro-neurophysiological tests. Advised as part of the neurological work-up of the patient. Elective tests may be asked for specific conditions that became obvious during patient work-up and urodynamic investigations.

5. SUPPLEMENTAL INVESTIGATIONS

5.1 Endoscopic procedures

Endoscopic investigation of the lower urinary tract may be necessary in a limited number of patients. The indication must be very restrictive.

5.2 Other investigations to define the neurological status

Specific investigations to assess the neurological status of the patient may also be necessary in individual cases.

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