The Standardisation of Terminology of Lower Urinary Tract Function

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1. Introduction

The International Continence Society established a committee for the standardisation of terminology of lower urinary tract function in 1973. Five of the six reports[1–5] from this committee, approved by the Society, have been published. The fifth report on “Quantification of urine loss”, was an internal I.C.S. document but appears, in part, in this document.

These reports are revised, extended and collated in this monograph. The standards are recommended to facilitate comparison of results by investigators who use urodynamic methods. These standards are recommended not only for urodynamic investigations carried out on humans but also during animal studies. When using urodynamic studies in animals the type of any anaesthesia used should be stated. It is suggested that acknowledgement of these standards in written publications be indicated by a footnote to the section “Methods and Materials” or its equivalent, to read as follows:

“Methods, definitions and units conform to the standards recommended by the International Continence Society, except where specifically noted”.

Urodynamic studies involve the assessment of the function and dysfunction of the urinary tract by any appropriate method. Aspects of urinary tract morphology, physiology, biochemistry and hydrodynamics affect urine transport and storage. Other methods of investigation such as the radiographic visualisation of the lower urinary tract is a useful adjunct to conventional urodynamics.

This monograph concerns the urodynamics of the lower urinary tract.

2. Clinical Assessment

The clinical assessment of patients with lower urinary tract dysfunction should consist of a detailed history, a frequency/volume chart and a physical examination. In urinary incontinence, leakage should be demonstrated objectively.

2.1. 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 assessment of menstrual, sexual and bowel function, and obstetric history.

The urinary history must consist of symptoms related to both the storage and the evacuation functions of the lower urinary tract.

2.2. 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 frequency/volume chart is very useful in the assessment of voiding disorders, and in the follow-up of treatment.

2.3. Physical Examination

Besides a general urological and, when appropriate, gynaecological examination, the physical examination should include the assessment of perineal sensation, the perineal reflexes supplied by the sacral segments S2-S4, and anal sphincter tone and control.

3. Procedures Related to the Evaluation of Urine Storage

3.1. Cystometry

Cystometry is the method by which the pressure/volume relationship of the bladder is measured. 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.

Cystometry is used to assess detrusor activity, sensation, capacity and compliance.

Before starting to fill the bladder the residual urine may be measured. However, the removal of a large volume of residual urine may alter detrusor function especially in neuropathic disorders. Certain cystometric parameters may be significantly altered by the speed of bladder filling (see 6.1.1.4.).

During cystometry it is taken for granted that the patient is awake, unanaesthetised and neither sedated nor taking drugs that affect bladder function. Any variations should be specified.

Specify

(a) Access (transurethral or percutaneous)

(b) Fluid medium (liquid or gas)

(c) Temperature of fluid (state in degrees Celsius)

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

(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 rate 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.

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.

Definitions

Intravesical pressure is the pressure within the bladder.

Abdominal pressure is taken to be the pressure surrounding the bladder. In current practice it is estimated from rectal or, less commonly, extraperitoneal pressure.

Detrusor pressure is that component of intravesical pressure that is created by forces in the bladder wall (passive and active). It is estimated by subtracting abdominal pressure from intravesical pressure. The simultaneous measurement of abdominal pressure is essential for the interpretation of the intravesical pressure trace. However, artefacts on the detrusor pressure trace may be produced by intrinsic rectal contractions.

Bladder sensation. Sensation is difficult to evaluate because of its subjective nature. It is usually assessed by questioning the patient in relation to the fullness of the bladder during cystometry.

Commonly used descriptive terms include:

First desire to void

Normal desire to void (this is defined as the feeling that leads the patient to pass urine at the next convenient moment, but voiding can be delayed if necessary).

Strong desire to void (this is defined as a persistent desire to void without the fear of leakage).

Urgency (this is defined as a strong desire to void accompanied by fear of leakage or fear of pain).

Pain (the site and character of which should be specified). Pain during bladder filling or micturition is abnormal.

The use of objective or semi-objective tests for sensory function, such as electrical threshold studies (sensory testing), is discussed in detail in 5.5.

The term “Capacity” must be qualified.

Maximum cystometric capacity, in patients with normal sensation, is the volume at which the patient feels he/she can no longer delay micturition. In the absence of sensation the maximum cystometric capacity cannot be defined in the same terms and is the volume at which the clinician decides to terminate filling. In the presence of sphincter incompetence the maximum cystometric capacity may be significantly increased by occlusion of the urethra e.g. by Foley catheter.

The *functional bladder capacity*, or voided volume is more relevant and is assessed from a frequency/volume chart (urinary diary).

The *maximum (anaesthetic) bladder capacity* is the volume measured after filling during a deep general or spinal/epidural anaesthetic, specifying fluid temperature, filling pressure and filling time.

Compliance indicates the change in volume for a change in pressure. Compliance is calculated by dividing the volume change (<delta>V) by the change in detrusor pressure (<delta>P_{det}) during that change in bladder volume (C = <delta>V/<delta>P_{det}). Compliance is expressed as ml per cmH_2O (see 6.1.1.4).

3.2. Urethral Pressure Measurement

It should be noted that the urethral pressure and the urethral closure pressure are idealised concepts which represent the ability of the urethra to prevent leakage (see 6.1.5). In current urodynamic practice the urethral pressure is measured by a number of different techniques which do not always yield consistent values. Not only do the values differ with the method of measurement but there is often lack of consistency for a single method. For example the effect of catheter rotation when urethral pressure is measured by a catheter mounted transducer.

Intraluminal urethral pressure may be measured:

(a) At rest, with the bladder at any given volume

(b) During coughing or straining

(c) During the process of voiding (see 4.4)

Measurements may be made at one point in the urethra over a period of time, or at several points along the urethra consecutively forming a *urethral pressure profile* (UPP).

Storage Phase

Two types of UPP may be measured:

(a) Resting urethral pressure profile – with the bladder and subject at rest.

(b) Stress urethral pressure profile – with a defined applied stress (e.g. cough, strain, Valsalva).

In the storage phase the *urethral pressure profile* denotes the intraluminal pressure along the length of the urethra. All systems are zeroed at atmospheric pressure. For external transducers the reference point is the superior edge of the symphysis pubis. For catheter mounted transducers the reference point is the transducer itself. Intravesical pressure should be measured to exclude a simultaneous detrusor contraction. The subtraction of intravesical pressure from urethral pressure produces the *urethral closure pressure profile.*

The simultaneous recording of both intravesical and intra-urethral pressures are essential during stress urethral profilometry.

Specify

(a) Infusion medium (liquid or gas)

(b) Rateofinfusion.

(c) Stationary, continuous or intermittent withdrawal.

(d) Rateofwithdrawal.

(e) Bladder volume.

(f) Position of patient (supine, sitting or standing).

Technique

(a) Open catheter – specify type (manufacturer), size, number, position and orientation of side or end hole.

(b) Catheter mounted transducers – specify manufacturer, number of transducers, spacing of transducers along the catheter, orientation with respect to one another; transducer design e.g. transducer face depressed or flush with catheter surface; catheter diameter and material. The orientation of the transducer(s) in the urethra should be stated.

(c) Other catheters, e.g. membrane, fibreoptic – specify type (manufacturer), size and number of channels as for microtransducer catheter.

(d) Measurement technique: For stress profiles the particular stress employed should be stated e.g. cough or Valsalva.

(e) Recording apparatus: Describe type of recording apparatus. The frequency response of the total system should be stated. The frequency response of the catheter in the perfusion method can be assessed by blocking the eyeholes and recording the consequent rate of change of pressure.

Definitions (Fig. A.1.2.1: Referring to profiles measured in storage phase).

Maximum urethral pressure is the maximum pressure of the measured profile.

Maximum urethral closure pressure is the maximum difference between the urethral pressure and the intravesical pressure.

Functional profile length is the length of the urethra along which the urethral pressure exceeds intravesical pressure.

Functional profile length (on stress) is the length over which the urethral pressure exceeds the intravesical pressure on stress.

FIGURE A.1.2.1 HERE
Fig. A.1.2.1 Diagram of a female urethral pressure profile (static) with I.C.S. recommended nomen

Pressure "transmission" ratio is the increment in urethral pressure on stress as a percentage of the simultaneously recorded increment in intravesical pressure. For stress profiles obtained during coughing, pressure transmission ratios can be obtained at any point along the urethra. If single values are given the position in the urethra should be stated. If several pressure transmission ratios are defined at different points along the urethra a pressure "transmission" profile is obtained. During "cough profiles" the amplitude of the cough should be stated if possible.

Note: the term "transmission" is in common usage and cannot be changed. However transmission implies a completely passive process. Such an assumption is not yet justified by scientific evidence. A role for muscular activity cannot be excluded.

Total profile length is not generally regarded as a useful parameter.

The information gained from urethral pressure measurements in the storage phase is of limited value in the assessment of voiding disorders.

3.3. Quantification of Urine Loss

Subjective grading of incontinence may not indicate reliably the degree of abnormality. However it is important to relate the management of the individual patients to their complaints and personal circumstances, as well as to objective measurements.

In order to assess and compare the results of the treatment of different types of incontinence in different centres, a simple standard test can be used to measure urine loss objectively in any subject. In order to obtain a representative result, especially in subjects with variable or intermittent urinary incontinence, the test should occupy as long a period as possible; yet it must be practical. The circumstances should approximate to those of everyday life, yet be similar for all subjects to allow meaningful comparison. On the basis of pilot studies performed in various centres, an internal report of the ICS (5th) recommended a test occupying a one-hour period during which a series of standard activities was carried out. This test can be extended by further one hour periods if the result of the first one hour test was not considered representative by either the patient or the investigator. Alternatively the test can be repeated having filled the bladder to a defined volume.

The total amount of urine lost during the test period is determined by weighing a collecting device such as a nappy, absorbent pad or condom appliance. A nappy or pad should be worn inside waterproof underpants or should have a waterproof backing. Care should be taken to use a collecting device of adequate capacity.

Immediately before the test begins the collecting device is weighed to the nearest gram.

Typical Test Schedule

(a) Test is started without the patient voiding.

(b) Preweighed collecting device is put on and first one hour test period begms.

(c) Subject drinks 500 ml sodium free liquid within a short period (max. 15 min), then sits or rests.

(d) Half hour period: subject walks, including stair climbing equivalent to one flight up and down.

(e) During the remaining period the subject performs the following activities:

(i) standing up from sitting, 10 times

(ii) coughing vigorously, 10 times

(iii) running on the spot for 1 minute

(iv) bending to pick up small object from floor, 5 times (v) wash hands in running water for 1 minute

(f) At the end of the one hour test the collecting device is removed and weighed.

(g) If the test is regarded as representative the subject voids and the volume is recorded.

(h) Otherwise the test is repeated preferably without voiding.

If the collecting device becomes saturated or filled during the test it should be removed and weighed, and replaced by a fresh device. The total weight of urine lost during the test period is taken to be equal to the gain in weight of the collecting device(s). In interpreting the results of the test it should be borne in mind that a weight gain of up to 1 gram may be due to weighing errors, sweating or vaginal discharge.

The activity programme may be modified according to the subject's physical ability. If substantial variations from the usual test schedule occur, this should be recorded so that the same schedule can be used on subsequent occasions.

In principle the subject should not void during the test period. If the patient experiences urgency, then he/she should be persuaded to postpone voiding and to perform as many of the activities in section (e) as possible in order to detect leakage. Before voiding the collection device is removed for weighing. If inevitable voiding cannot be postponed then the test is terminated. The voided volume and the duration of the test should be recorded. For subjects not completing the full test the results may require separate analysis, or the test may be repeated after rehydration.

The test result is given as grams urine lost in the one hour test period in which the greatest urine loss is recorded.

Additional Procedures

Additional procedures intended to give information of diagnostic value are permissible provided they do not interfere with the basic test. For example, additional changes and weighing of the collecting device can give information about the timing of urine loss. The absorbent nappy may be an electronic recording nappy so that the timing is recorded directly.

Presentation of Results

Specify

(a) collecting device

(b) physical condition of subject (ambulant, chairbound, bedridden)

(c) relevant medical condition of subject

(d) relevant drug treatments

(e) test schedule

In some situations the timing of the test (e.g. in relation to the menstrual cycle) may be relevant.

Findings

Record weight of urine lost during the test (in the case of repeated tests, greatest weight in any stated period). A loss of less than one gram is within experimental error and the patients should be regarded as essentially dry. Urine loss should be measured and recorded in grams.

Statistics

When performing statistical analysis of urine loss in a group of subjects, nonparametric statistics should be employed, since the values are not normally distributed.

4. Procedures Related to the Evaluation of Micturition

4.1. Measurement of Urinary Flow

Urinary flow may be described in terms of *rate* and *pattern* and may be *continuous* or *intermittent*. *Flow rate* is defined as the volume of fluid expelled via the urethra per unit time. It is expressed in ml/s.

Specify

(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) typeoffluid.

Technique

(a) Measuring equipment.
(b) Solitary procedure or combined with other measurements.

Definitions

(a) *Continuous flow* (Fig. A.1.2.2)

Voided volume is the total volume expelled via the urethra.

Maximum flow rate is the maximum measured value of the flow rate

Average flow rate is voided volume divided by flow time. The calculation of average flow rate is only meaningful if flow is continuous and without terminal dribbling.

Flow time is the time over which measurable flow actually occurs.

Time to maximum flow is the elapsed time from onset of flow to maximum flow.

The flow pattern must be described when flow time and average flow rate are measured.

FIGURE A.1.2.2 HERE

Fig. A.1.2.2 Diagram of a continuous urine flow recording with ICS recommended nomenclature.

FIGURE A.1.2.3 HERE

Fig. A.1.2.3 Diagram of an interrupted urine flow recording with ICS recommended nomenclature.

(b) *Intermittent flow* (Fig. A.1.2.3)

The same parameters used to characterise continuous flow may be applicable if care is exercised in patients with intermittent flow. In measuring flow time the time intervals between flow episodes are disregarded.

Voiding time is total duration of micturition, i.e. includes interruptions. When voiding is completed without interruption, voiding time is equal to flow time.

4.2. Bladder Pressure Measurements During Micturition

The specifications of patient position, access for pressure measurement, catheter type and measuring equipment are as for cystometry (see 3.1).

Definitions (Fig. A.1.2.4)

Opening Time is the elapsed time from initial rise in detrusor pressure to onset of flow. This is the initial isovolumetric contraction period of micturition. Time legs should be taken into account. In most urodynamic systems a time lag occurs equal to the time taken for the urine to pass from the point of pressure measurement to the uroflow transducer.

The following parameters are applicable to measurements of each of the pressure curves: intravesical, abdominal and detrusor pressure.

Premicturition pressure is the pressure recorded immediately before the initial isovolumetric contraction.

Opening pressure is the pressure recorded at the onset of measured flow.

Maximum pressure is the maximum value of the measured pressure.

Pressure at maximum flow is the pressure recorded at maximum measured flow rate.

Contraction pressure at maximum flow is the difference between pressure at maximum flow and premicturition pressure.

Postmicturition events (e.g. after contraction) are not well understood and so cannot be defined as yet.

FIGURE HERE

Fig. A.1.2.4. Diagram of a pressure-flow recording of micturition with I.C.S. recommended nomenclature.

4.3. Pressure-Flow Relationships

In the early days of urodynamics the flow rate and voiding pressure were related as a “urethral resistance factor”. The concept of a resistance factor originates from rigid tube hydrodynamics. The urethra does not generally behave as a rigid tube as it is an irregular and distensible conduit whose walls and surroundings have active and passive elements and, hence, influence the flow through it. Therefore a resistance factor cannot provide a valid comparison between patients.

There are many ways of displaying the relationships between flow and pressure during micturition; an example is suggested in the ICS 3rd Report (Fig. A.1.2.5). As yet available data do not permit a standard presentation of pressure/flow parameters.

When data from a group of patients are presented, pressure-flow relationships may be shown on a graph as illustrated in Fig. A.1.2.5. This form of presentation allows lines of demarcation to be drawn on the graph to separate the results according to the problem being studied. The points shown in Fig. A.1.2.5 are purely illustrative to indicate how the data might fall into groups. The group of equivocal results might include either an unrepresentative micturition in an obstructed or an unobstructed patient, or underactive detrusor function with or without obstruction. This is the group which invalidates the use of “urethral resistance factors”.

FIGUREHERE

Fig. A.1.2.5 Diagram illustrating the presentation of pressure flow data on individual patients in three groups of 3 patients: obstructed, equivocal and unobstructed.

4.4. Urethral Pressure Measurements During Voiding (VUPP)

The VUPP is used to determine the pressure and site of urethral obstruction.

Pressure is recorded in the urethra during voiding. The technique is similar to that used in the UPP measured during storage (the resting and stress profiles 3.2).

Specify

As for UPP during storage (3.2).

Accurate interpretation of the VUPP depends on the simultaneous measurement of intravesical pressure and the measurement of pressure at a precisely localised point in the urethra. Localisation may be achieved by radio opaque marker on the catheter which allows the pressure measurements to be related to a visualised point in the urethra.

This technique is not fully developed and a number of technical as well as clinical problems need to be solved before the VUPP is widely used.

4.5. Residual Urine

Residual urine is defined as the volume of fluid remaining in the bladder immediately following the completion of micturition. The measurement of residual urine forms an integral part of the study of micturition. However voiding in unfamiliar surroundings may lead to unrepresentative results, as may vo~dmg on command with a partially filled or overfilled bladder. Residual urine is commonly estimated by the following methods:

(a) Catheter or cystoscope (transurethral, suprapubic).

(b) Radiography (excretion urography, micturition cystography).

(c) Ultrasonics.

(d) Radioisotopes (clearance, gamma camera).

When estimating residual urine the measurement of voided volume and the time interval between voiding and residual urine estimation should be recorded: this is particularly important if the patient is in a diuretic phase. In the condition of vesicoureteric reflux, urine may re-enter the bladder after micturition and may falsely be interpreted as residual urine. The presence of urine in bladder diverticula following micturition presents special problems of interpretation, since a diverticulum may be regarded either as part of the bladder cavity or as outside the functioning bladder.

The various methods of measurement each have limitations as to their applicability and accuracy in the various conditions associated with residual urine. Therefore it is necessary to choose a method appropriate to the clinical problems. The absence of residual urine is usually an observation of clinical value, but does not exclude infravesical obstruction or bladder dysfunction. An isolated finding of residual urine requires confirmation before being considered significant.

5. Procedures Related to Neurophysiological Evaluation of the Urinary Tract During Filling and Voiding

5.1. Electromyography

Electromyography (EMG) is the study of electrical potentials generated by the depolarization of muscle. The following refers to striated muscle EMG The functional unit in EMG is the motor unit. This is comprised of a single motor neurone and the muscle fibres it innervates. A motor unit action potential is the recorded depolarisation of muscle fibres which results from activation of a single anterior horn cell. Muscle action potentials may be detected either by needle electrodes, or by surface electrodes.

Needle electrodes are placed directly into the muscle mass and permit visualisation of the individual motor unit action potentials.

Surface electrodes are applied to an epithelial surface as close to the muscle under study as possible. Surface electrodes detect the action potentials from groups of adjacent motor units underlying the recording surface.

EMG potentials may be displayed on an oscilloscope screen or played through audio amplifiers. A permanent record of EMG potentials can only be made using a chart recorder with a high frequency response (in the range of 10 kHz).

EMG should be interpreted in the light of the patients symptoms, physical findings and urological and urodynamic investigations.

General Information

Specify

(a) EMG (solitary procedure, part of urodynamic or other electrophysiological investigation).

(b) Patient position (supine, standing, sitting or other).

(c) Electrode placement:

(i) Sampling site (intrinsic striated muscle of the urethra, periurethral striated muscle, bulbocavernosus muscle, external anal sphincter, pubococcygeus or other). State whether sites are single or multiple, unilateral or bilateral. Also state number of samples per site.

(ii) Recording electrode: define the precise anatomical location of the electrode. For needle electrodes, include site of needle entry, angle of entry and needle depth. For vaginal or urethral surface electrodes state method of determining position of electrode.

(iii) Reference electrode position.

Note: ensure that there is no electrical interference with any other machines, e.g. X-ray apparatus.

Technical Information

Specify

(a) Electrodes
(i) Needle electrodes
– design (concentric, bipolar, monopolar, single fibre, other)
– dimensions (length, diameter, recording area).
– electrode material (e.g. platinum).
(ii) Surface electrodes
– type (skin, plug, catheter, other)
– size and shape electrode material
– mode of fixation to recording surface
– conducting medium (e.g. saline, jelly)

(b) Amplifier (make and specifications)

(c) Signal processing (data: raw, averaged, integrated or other)

(d) Display equipment (make and specifications to include method of calibration, time base, full scale deflection in microvolts and polarity).

(i) oscilloscope
(ii) chart recorder
(iii) loudspeaker
(iv) other

(e) Storage (make and specifications)

(i) paper
(ii) magnetic tape recorder
(iii) microprocessor
(iv) other

(f) Hard copy production (make and specifications)
(i) chart recorder
(ii) photographic/video reproduction of oscilloscope screen
(iii) other

EM6 Findings

(a) Individual motor unit action potentials – Normal motor unit potentials have a characteristic configuration, amplitude and duration. Abnormalities of the motor unit may include an increase in the amplitude, duration and complexity of waveform (polyphasicity) of the potentials. A polyphasic potential is defined as one having more than 5 deflections. The EMG findings of fibrillations, positive sharp waves and bizarre high frequency potentials are thought to be abnormal.

(b) Recruitment patterns – In normal subjects there is a gradual increase in “pelvic floor” and “sphincter” EMG activity during bladder filling. At the onset of micturition there is complete absence of activity. Any sphincter EMG activity during voiding is abnormal unless the patient is attempting to inhibit micturition. The finding of increased sphincter EMG activity, during voiding, accompanied by characteristic simultaneous detrusor pressure and flow changes is described by the term, detrusorsphincter-dyssynergia. In this condition a detrusor contraction occurs concurrently with an in appropriate contraction of the urethral and or periurethral striated muscle.

5.2. Nerve Conduction Studies

Nerve conduction studies involve stimulation of a peripheral nerve, and recording the time taken for a response to occur in muscle, innervated by the nerve under study. The time taken from stimulation of the nerve to the response in the muscle is called the “latency”. Motor latency is the time taken by the fastest motor fibres in the nerve to conduct impulses to the muscle and depends on conduction distance and the conduction velocity of the fastest fibres.

General Information

(also applicable to reflex latencies and evoked potentials – see below).

Specify

(a) Type of investigation
(i) nerve conduction study (e.g. pudendal nerve)
(ii) reflex latency determination (e.g. bulbocavernosus)
(iii) spinal evoked potential
(iv) cortical evoked potential
(v) other

(b) Is the study a solitary procedure or part of urodynamic or neuro-physiological investigations?

(c) Patient position and environmental temperature, noise level and illumination.

(d) Electrode placement: Define electrode placement in precise anatomical

terms. The exact interelectrode distance is required for nerve conduction velocity calculations.

(i) Stimulation site (penis, clitoris, urethra, bladder neck, bladder or other).

(ii) Recording sites (external anal sphincter, periurethral striated muscle, bulbocavernosus muscle, spinal cord, cerebral cortex or other).

When recording spinal evoked responses, the sites of the recording electrodes should be specified according to the bony landmarks (e.g. L4). In cortical evoked responses the sites of the recording electrodes should be specified as in the International 10-20 system.6 The sampling techniques should be specified (single or multiple, unilateral or bilateral, ipsilateral or contralateral or other).

(iii) Reference electrode position.

(iv) Grounding electrode site: ideally this should be between the stimulation and recording sites to reduce stimulus artefact.

Technical Information

(also applicable to reflex latencies and evoked potential – see below)

Specify

(a) Electrodes (make and specifications). Describe *separately* stimulus and recording electrodes as below.

(i) design (e.g. needle, plate, ring, and configuration of anode and cathode where applicable).
(ii) dimensions
(iii) electrode material (e.g. platinum)
(iv) contact medium

(b) Stimulator (make and specifications)

(i) stimulus parameters (pulse width, frequency, pattern, current density, electrode impedance in Kohms. Also define in terms of threshold e.g. in case of supramaximal stimulation).

(c) Amplifier (make and specifications)

(i) sensitivity (mV-<mu>V)
(ii) filters – low pass (Hz) or high pass (kHz)
(iii) sampling time (ms)

(d) Averager (make and specifications)

(i) number of stimuli sampled

(e) Display equipment (make and specifications to include method of calibration, time base, full scale deflection in microvolts and polarity).

(i) oscilloscope

(f) Storage (make and specifications)
(i) paper
(ii) magnetic tape recorder
(iii) microprocessor
(iv) other

(g) Hard copy production (make and specification)
(i) chart recorder
(ii) photographic/video reproduction of oscilloscope screen
(iii) XY recorder
(iv) other

Description of Nerve Conduction Studies

Recordings are made from muscle and the latency of response of the muscle is measured. The latency is taken as the time to onset, of the earliest response.

(a) To ensure that response time can be precisely measured, the gain should be increased to give a clearly defined takeoff point. (Gain setting at least 100 ~V/div and using a short time base e.g. 1-2 ms/div).

(b) Additional information may be obtained from nerve conduction studies, if, when using surface electrodes to record a compound muscle action potential, the amplitude is measured. The gain setting must be reduced so that the whole response is displayed and a longer time base is recommended (e.g. 1 mV/div and 5 ms/div). Since the amplitude is proportional to the number of motor unit potentials within the vicinity of the recording electrodes, a reduction in amplitude indicates loss of motor units and therefore denervation. (Note: A prolongation of latency is not necessarily indicative of denervation.)

5.3. Reflex Latencies

Reflex latencies require stimulation of sensory fields and recordings from the muscle which contracts reflexy in response to the stimulation. Such responses are a test of reflex arcs which are comprised of both afferent and efferent limbs and a synaptic region within the central nervous system. The reflex latency expresses the nerve conduction velocity in both limbs of the arc and the integrity of the central nervous system at the level of the synapse(s). Increased reflex latency may occur as a result of slowed afferent or efferent nerve conduction or due to central nervous system conduction delays.

General Information and Technical Information

The same technical and general details apply as discussed above under Nerve Conduction Studies (5.2).

Description of Reflex Latency Measurements

Recordings are made from muscle and the latency of response of the muscle is measured. The latency is taken as the time to onset, of the earliest response.

To ensure that response time can be precisely measured, the gain should be increased to give a clearly defined take-offpoint. (Gain setting at least 100 ,uV/div and using a short time base e.g. 1-2 ms/div.)

5.4 Evoked Responses

Evoked responses are potential changes in central nervous system neurones resulting from distant stimulation usually electrical. They are recorded using averaging techniques. Evoked responses may be used to test the integrity of peripheral, spinal and central nervous pathways. As with nerve conduction studies, the conduction time (latency) may be measured. In addition, information may be gained from the amplitude and configuration of these responses.

General Information and Technical Information

See above under Nerve Conduction Studies (5.2).

Description of Evoked Responses

Describe the presence or absence of stimulus evoked responses and their configuration.

Specify

(a) Single or multiphasic response.

(b) Onset of response: defined as the start of the first reproducible potential. Since the onset of the response may be difficult to ascertain precisely, the criteria used should be stated.

(c) Latency to onset: defined as the time (ms) from the onset of stimulus to the onset of response. The central conduction time relates to cortical evoked potentials and is defined as the difference between the latencies of the cortical and the spinal evoked potentials. This parameter may be used to test the integrity of the corticospinal neuraxis.

(d) Latencies to peaks of positive and negative deflections in multiphasic responses (Fig. A.1.2.6). P denotes positive deflections, N denotes negative deflections. In multiphasic responses, the peaks are numbered consecutively (e.g. P1, N1, P2, N2 ...) or according to the latencies to peaks in milliseconds (e.g. P44, N52, P6[[6]] ...).

(e) The amplitude of the responses is measured in ,u V.

FIGUREHERE

Fig. A.1.2.6 Multiphasic evoked response recorded from the cerebral cortex after stimulation of the dorsal aspect of the penis. The recording shows the conventional labelling of negative (N) and positive (P) deflections with the latency of each deflection from the point of stimulation in milliseconds.

5.5. Sensory Testing

Limited information, of a subjective nature, may be obtained during cystometry by recording such parameters as the first desire to micturate, urgency or pain. However, sensory function in the lower urinary tract, can be assessed by semi-objective tests by the measurement of urethral and/or vesical sensory thresholds to a standard applied stimulus such as a known electrical current.

General Information

Specify

(a) Patient's position (supine, sitting, standing, other)
(b) Bladder volume at time of testing
(c) Site of applied stimulus (intravesical, intraurethral)

(d) Number of times the stimulus was applied and the response recorded. Define the sensation recorded, e.g. the first sensation or the sensation of pulsing.

(e) Type of applied stimulus

(i) electrical current: it is usual to use a constant current stimulator in urethral sensory measurement

– state electrode characteristics and placement as in section on EMG.

– state electrode contact area and distance between electrodes if applicable

– state impedance characteristics of the system

– state type of conductive medium used for electrode/epithelial contact. *Note: topical anaesthetic agents should not be used.*

– stimulator make a specifications.

– stimulation parameters (pulse width, frequency, pattern, duration, current density).

(ii) other – e.g. mechanical, chemical.

The vesical/urethral sensory threshold is defined as the least current which consistently produces a sensation perceived by the subject during stimulation at the site under investigation. However, the absolute values will vary in relation to the site of the stimulus, the characteristics of the equipment and the stimulation parameters. Normal values should be established for each system.

6. A Classification of Urinary Tract Dysfunction

The lower urinary tract is composed of the *bladder* and *urethra*. They form a functional unit and their interaction cannot be ignored. Each has two functions, the bladder to store and void, the urethra to control and convey. When a reference is made to the hydrodynamic function or to the whole anatomical unit as a storage organ – the vesica urinaria – the correct term is the *bladder*. When the smooth muscle structure known as the m. detrusor urinae is being discussed then the correct term is *detrusor*. For simplicity the bladder/detrusor and the urethra will be considered separately so that a classification based on a combination of functional anomalies can be reached. Sensation cannot be precisely evaluated but must be assessed. This classification depends on the results of various objective urodynamic investigations. A complete urodynamic assessment is not necessary in all patients. However, studies of the filling and voiding phases are essential for each patient. As the bladder and urethra may behave differently during the storage and micturition phases of bladder function it is most useful to examine .bladder and urethral activity separately in each phase.

Terms used should be objective, definable and ideally should be applicable to the whole range of abnormality. When authors disagree with the classification presented below, or use terms which have not been defined here, their meaning should be made clear.

Assuming the absence of inflammation, infection and neoplasm, lower urinary tract dysfunction may be caused by:

(a) Disturbance of the pertinent nervous or psychological control system.

(b) Disorders of muscle function.

(c) Structural abnormalities.

Urodynamic diagnoses based on this classification should correlate with the patient's symptoms and signs. For example the presence of an unstable contraction in an asymptomatic continent patient does not warrant a diagnosis of detrusor overactivity during storage.

6.1. The Storage Phase

6.1.1. Bladder Function During Storage

This may be described according to:

6.1.1.1 Detrusor activity

6.1.1.2 Bladder sensation
6.1.1.3 Bladder capacity
6.1.1.4 Compliance

6.1.1.1 *Detrusor activity* In this context detrusor activity is interpreted from the measurement of detrusor pressure (P_{det}).

Detrusor activity may be:

(a) Normal

(b) Overactive

(a) *Normal detrusor function* During the filling phase the bladder volume increases without a significant rise in pressure (accommodation). No involuntary contractions occur despite provocation.

A normal detrusor so defined may be described as “stable”.

(b) *Overactive detrusor function* Overactive detrusor function is characterised by involuntary detrusor contractions during the filling phase, which may be spontaneous or provoked and which the patient cannot completely suppress. Involuntary detrusor contractions may be provoked by rapid filling, alterations of posture, coughing, walking, jumping and other triggering procedures. Various terms have been used to describe these features and they are defined as follows:

The *unstable detrusor* is one that is shown objectively to contract, spontaneously or on provocation, during the filling phase while the patient is attempting to inhibit micturition. Unstable detrusor contractions may be asymptomatic or may be interpreted as a normal desire to void. The presence of these contractions does not

Fig. A.1.2.7 Diagrams of filling cyslometry to illustrate:

a Typical phasic unstable detrusor contraction.
b The gradual increase of detrusor pressure with filling characteristic of reduced bladder compliance.

necessarily imply a neurological disorder. Unstable contractions are usually phasic in type (Fig. A.1.2.7a). A gradual increase in detrusor pressure without subsequent decrease is best regarded as a change of compliance (Fig. A.1.2.7b).

Detrusor hyperreflexia is defined as overactivity due to disturbance of the nervous control mechanisms. The term detrusor hyperreflexia should only be used when there is objective evidence of a relevant neurological disorder. The use of conceptual and undefined terms such as hypertonic, systolic, uninhibited, spastic and automatic should be avoided.

6.1.1.2. *Bladder Sensation* Bladder sensation during filling can be classified in qualitative terms (see 3.1) and by objective measurement (see 5.5). Sensation can be classified broadly as follows:

(a) Normal
(b) Increased (hypersensitive)
(c) Reduced (hyposensitive)
(d) Absent

6.1.1.3 *Bladder Capacity* (see 3.1.)

6.1.1.4 *Compliance* is defined as: <delta>V/<delta>p (see 3.1.).

Compliance may change during the cystometric examination and is variably dependent upon a number of factors including:

(a) Rate of filling
(b) The part of the cystometrogram curve used for compliance calculation
(c) The volume interval over which compliance is calculated
(d) The geometry (shape) of the bladder
(e) The thickness of the bladder wall
(f) The mechanical properties of the bladder wall
(g) The contractile/relaxant properties of the detrusor

During normal bladder filling little or no pressure change occurs and this is termed “normal compliance”. However at the present time there is insufficient data to define normal, high and low compliance.

When reporting compliance, specify:

(a) The rate of bladder filling
(b) The bladder volume at which compliance is calculated
(c) The volume increment over which compliance is calculated
(d) The part of the cystometrogram curve used for the calculation of compliance.

6.1.2. Urethral Function During Storage

The urethral closure mechanism during storage may be:

(a) Normal
(b) Incompetent

(a) The *normal urethral closure* mechanism maintains a positive urethral closure pressure during filling even in the presence of increased abdominal pressure. Immediately prior to micturition the normal closure pressure decreases to allow flow.

(b) *Incompetent urethral closure mechanism*. An incompetent urethral closure mechanism is defined as one which allows leakage of urine in the absence of a detrusor contraction. Leakage may occur whenever intravesical pressure exceeds intraurethral pressure (genuine stress incontinence) or when there is an involuntary fall in urethral pressure. Terms such as “the unstable urethra” await further data and precise definition.

6.1.3. Urinary Incontinence

Urinary incontinence is involuntary loss of urine which is objectively demonstrable and a social or hygienic problem. Loss of urine through channels other than the urethra is extraurethral incontinence.

Urinary incontinence denotes:

(a) A symptom
(b) A sign
(c) A condition

The symptom indicates the patient’s statement of involuntary urine loss.

The sign is the objective demonstration of urine loss.

The condition is the urodynamic demonstration of urine loss.

Symptoms

Urge incontinence is the involuntary loss of urine associated with a strong desire to void (urgency).

Urgency may be associated with two types of dysfunction:

(a) Overactive detrusor function (*motor urgency*)
(b) Hypersensitivity (*sensory urgency*)

Stress incontinence: the symptom indicates the patient’s statement of involuntary loss of urine during physical exertion.

“Unconscious” incontinence. Incontinence may occur in the absence of urge and without conscious recognition of the urinary loss.

Enuresis means any involuntary loss of urine. If it is used to denote incontinence during sleep, it should always be qualified with the adjective “nocturnal”.

Post-micturition dribble and *Continuous leakage* denote other symptomatic forms of incontinence.

Signs

The sign stress-incontinence denotes the observation of loss of urine from the urethra synchronous with physical exertion (e.g. coughing). Incontinence may also be observed without physical exercise. Post-micturition dribble and continuous leakage denotes other signs of incontinence. Symptoms and signs alone may not disclose the cause of urinary incontinence. Accurate diagnosis often requires urodynamic investigation in addition to careful history and physical examination.

Conditions

Genuine stress incontinence is the involuntary loss of urine occurring when, in the absence of a detrusor contraction, the intravesical pressure exceeds the maximum urethral pressure.

Reflex incontinence is loss of urine due to detrusor hyperreflexia and/or involuntary urethral relaxation in the absence of the sensation usually associated with the desire to micturate. This condition is only seen in patients with neuropathic bladder/urethral disorders.

Overflow incontinence is any involuntary loss of urine associated with overdistension of the bladder.

6.2. TheVoiding Phase

6.2.1. The Detrusor During Voiding

During micturition the detrusor may be:

(a) acontractile
(b) underactive
(c) normal

(a) *The acontractile detrusor* is one that cannot be demonstrated to contract during urodynamic studies. *Detrusor areflexia* is defined as acontractility due to an abnormality of nervous control and denotes the complete absence of centrally coordinated contraction. In detrusor areflexia due to a lesion of the conus medullaris or sacral nerve outflow, the detrusor should be described as *decentralised* – not denervated, since the peripheral neurones remain. In such bladders pressure fluctuations of low amplitude, sometimes known as “autonomous” waves, may occasionally occur. The use of terms such as atonic, hypotonic, autonomic and flaccid should be avoided.

(b) *Detrusor underactivity*. This term should be reserved as an expression describing detrusor activity during micturition. Detrusor underactivity is defined as a detrusor contraction of inadequate magnitude and/or duration to effect bladder emptying with a normal time span. Patients may have underactivity during micturition and detrusor overactivity during filling.

(c) *Normal detrusor contractility*. Normal voiding is achieved by a voluntarily initiated detrusor contraction that is sustained and can usually be suppressed voluntarily. A normal detrusor contraction will effect complete bladder emptying in the absence of obstruction. For a given detrusor contraction, the magnitude of the recorded pressure rise will depend on the degree of outlet resistance.

6.2.2. Urethral Function During Micturition

During voiding urethral function may be:

(a) normal
(b) obstructive
 – overactivity
 – mechanical

(a) *The normal urethra* opens to allow the bladder to be emptied.

(b) *Obstruction due to urethral overactivity*: this occurs when the urethral closure mechanism contracts against a detrusor contraction or fails to open at attempted micturition. Synchronous detrusor and urethral contraction is *detrusor/urethral dyssynergia*. This diagnosis should be qualified by stating the location and type of the urethral muscles (striated or smooth) which are involved. Despite the confusion surrounding “sphincter” terminology the use of certain terms is so widespread that they are retained ancl defined here. The term *detrusor/external sphincter dyssynergia or detrusor-sphincter dyssynergia* (DSD) describes a detrusor contraction concurrent with an involuntary contraction of the urethral and/or periurethral striated muscle. In the adult, detrusor sphincter dyssynergia is a feature of neurological voiding disorders. In the absence of neurological features the validity of this diagnosis should be questioned. The term *detrusor/bladder neck dyssynergia* is used to denote a detrusor contraction concurrent with an objectively demonstrated failure of bladder neck opening. No parallel term has been elaborated for possible detrusor/distal urethral (smooth muscle) dyssynergia.

Overactivity of the striated urethral sphincter may occur in the absence of detrusor contraction, and may prevent voiding. This is not detrusor/sphincter dyssynergia.

Overactivity of the urethral sphincter may occur during voiding in the absence of neurological disease and is termed *dysfunctional voiding*. The use of terms such as “non-neurogenic” or “occult neuropathic” should be avoided.

Mechanical obstruction: is most commonly anatomical e.g. urethral stricture.

Using the characteristics of detrusor and urethral function during storage and micturition an accurate definition of lower urinary tract behaviour in each patient becomes possible.

7. Units of Measurement

In the urodynamic literature pressure is measured in cmH_2O and not in millimetres of mercury. When Laplace's law is used to calculate tension in the bladder wall, it is often found that pressure is then measured in dyne cm^{-2}. This lack of uniformity in the systems used leads to confusion when other parameters, which are a function of pressure, are computed, for instance, "compliance", contraction force, velocity etc. From these few examples it is evident that standardisation is essential for meaningful communic-a~iOn. Many journals now requ~re that the results be given in SI units. This section is designed to give guidance in the application of the SI system to urodynamics and defines the units involved. The principal units to be used are listed below (Table I).

Table 1.

Quantity	Acceptable unit	Symbol
volume	millilitre	ml
time	second	s
flow rate	millilitres/second	ml s^{-1}
pressure	centimetres of water[a]	cmH_2O
length	metres or submultiples	m, cm, mm
velocity	metres/second or submultiples	m s^{-1}, cm s^{-1}
temperature	degrees Celsius	°C

[a]The SI Unit is the pascal (Pa), but it is only practical at present to calibrate our instruments in cmH_2O. One centimetre of water pressure is approximately equal to 100 pascals (1 cmH_2O = 98.07 Pa = 0.098 kPa).

Table II. List of symbols

Basic symbols		Urological qualifiers		Value
Pressure	p max	Bladder	ves	Maximum (max)
Volume	V min	Urethra	ura	Minimum (min)
Flow rate	Q ave	Ureter	ure	Average (ave)
Velocity	v isv	Detrusor	det	Isovolumetric (isv)
Time	t ist	Abdomen	abd	Isotonic (ist)
Temperature	T	External		Isobaric (isb)
Length	I	stream	ext	Isometric (ism)
Area	A			
Diameter	d			

Force	F
Energy	E
Power	P
Compliance	P
Work	W
Energy per unit volume	e

Examples: $P_{det,max}$ = maximum detrusor pressure
e_{ext} = kinetic energy per unit volume in the external stream

Symbols

It is often helpful to use symbols in a communication. The system in Table II has been devised to standardise a code of symbols for use in urodynamics. The rationale of the system is to have a basic symbol representing the physical quantity with qualifying subscripts. The list of basic symbols largely conforms to international usage. The qualifying subscripts relate to the basic symbols to commonly used urodynamic parameters.

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