Received: 6 September 2016 | Accepted: 19 September 2016

DOI 10.1002/nau.23181

REVIEW ARTICLE

WILEY Neurourology Urodynamics ICS SUFU

ICS teaching module: Cystometry (basic module)

Carlos Arturo Levi D'Ancona[1] | **Mario João Gomes**[2] | **Peter F.W.M. Rosier**[3]

[1] Division of Urology, University of Campinas School of Medicine, Campinas, Sao Paulo, Brazil

[2] In remembrance: Hospital Santo Antonio, Porto, Portugal

[3] Department of Urology, University Medical Center Utrecht, The Netherlands

Correspondence
Carlos Arturo Levi D'Ancona, Division of Urology, University of Campinas School of Medicine, Campinas, Sao Paulo, Brazil.
Email: cdancona@uol.com.br

Aims: To summarize the evidence background for education of good urodynamic practice, especially cystometry.
Methods: A search was done in PubMed for the last 5 years of publications selecting only clinical studies, utilizing the following keywords: cystometry 133 articles and filling cystometry 53 articles.
Results: The evidence with regard to clinical setting and cystometry technique, as well as for catheters and transducers type, infused solution and patient position is presented with recommendations. Also the practice of determining bladder filling sensation and capacity and the basis of detrusor storage function diagnosis is educated.
Conclusions: This manuscript provides the evidence background for the practice of cystometry.

KEYWORDS
cystometry, urodynamics

1 | INTRODUCTION

Cystometry is the method by which the storage function of the lower urinary tract (LUT) is measured during the filling of the bladder.[1,3] The aim of urodynamics is to find an objective, pathophysiological, explanation for the patient's LUT symptoms and to answer the clinical (or research) question.[3–5] Cystometry is an important part of invasive urodynamics as it evaluates the storage function of the bladder. Invasive urodynamics, that is, cystometry requires insertion of catheters and technical instrumentation and also depends on cooperation of the patient. Urodynamics is a replication of the LUT physiology in a laboratory situation and the interpretation should be made with specific attention to representativeness, technical details, as well as clinical relevance. Cystometry is the golden standard for LUT storage function assessment.[1–5]

The ICS Urodynamics Committee presents this teaching module "Cystometry" as standard education of Good Urodynamic Practice[2,3] for everyone involved with indicating, performing, and analyzing urodynamic testing. The teaching module consists of a presentation, in combination with this manuscript. This manuscript serves as a scientific background review; the evidence base, for the ICS PowerPoint presentation; available via http://www.icsoffice.org/eLearning/...... The presentation explains normal physiology, testing requirements, practice of testing, and analysis methods.

1.1 | Clinical setting

Cystometry is part of invasive urodynamic investigation and contemporary guidelines recommend that a LUT symptom questionnaire, a voiding diary, clinical examination, and laboratory urine exam preceded invasive testing. Usually uroflowmetry and a post void residual urine (PVR) are also recommended before further testing. The voiding diary informs about the range of the volume of micturition and the frequency of voiding. Uroflowmetry and PVR are recommended for clinical reasons but also relevant to evaluate the representativeness of pressure flow analysis (not further discussed here). For the practice of cystometry however, PVR is also informative to be aware of the "hidden" capacity of the bladder, not visible on the voiding diary.

Dr. Alan Wein led the peer-review process as the Associate Editor responsible for the paper.

Voided volumes (including PVR) provide a clue to the urodynamic capacity that can be expected. Cystometry should result in a diagnosis of detrusor (muscle volumeadaptation) function and bladder compliance as well as diagnoses of bladder filling sensation and cystometric (bladder) capacity.[1] Clinical stress-testing during examination can demonstrate urine loss however cystometry allows stress (urinary incontinence) testing while intravesical volume and pressures are monitored, allowing to control for detrusor activity.[6,7] All this information gives the urodynamic diagnosis of storage phase function and is basis for management of patients with symptoms and signs of LUTD.[5] The cystometry starts (after insertion of the catheters) when the infusion begins and ends when the infusion stops under the command of the patient and/or decision of the urodynamicist.[1–3] Cystometry may also end with loss (incontinence) of total bladder volume.

1.2 | Technique of cystometry

Catheterization is performed trans-urethral however, can also be done via the suprapubic route. ICS standard requires fluid filled catheters connected to an external pressure transducer. Simultaneous recording of abdominal pressure (Pabd) is also standard and can be obtained with the use of a catheter in the rectum and connected to a pressure transducer.[1–3]

The external transducers are positioned at the level of the upper border of symphysis pubic and zeroed at atmospheric pressure before connecting to the catheters, or via a tree-way stopcock while connected.[3] Air bubbles in the connecting tubes and catheters cause dampening of the pressure transmission and should be removed from the system before insertion and measuring.

Before and during the exam, it is necessary to verify that both pressures are registering by asking the patient to cough.[3] The amplitude of pves and pabd should be similar. The vital signs of respiration, talking of the patient, and movement should be visible in pves and pabd throughout the entire cystometry as a sign of pressure registering quality.[2,8,9] Rectal contractions may occur during cystometry and should not be misinterpreted as detrusor overactivity in the pdet trace.[9] On the other hand classification of intensity and frequency of rectal contractions may be of relevance.[10]

1.3 | Types of catheters

A double lumen catheter, as thin as possible (usually 7-8F), is ICS good urodynamic practices standard. A double lumen catheter requires an infusion pump on the filling lumen. Using a double lumen catheter allows a smooth transition from storage to voiding and permits the exam to be repeated without reinsertion of a filling catheter.

A double lumen catheter may be considered too expensive in some health care systems and in that case a 6F catheter is inserted together with a filling catheter (usually 8-10F) that is removed at the end of the filling to avoid excess obstruction during voiding. Abdominal pressure, surrounding the bladder in the lower pelvis, is measured with a, preferably punctured, balloon filled with a small amount of fluid to prevent clogging of the catheter by rectal content, but may also be an open fluid filled tube without balloon.[2,3] Vaginal placing or via a stoma are alternatives when the rectum is closed. Although this is—especially stoma placement—less reliable.

The size of the abdominal pressure catheter is preferably similar to that of the Pves so that the same sensitiveness to transfer the pressure is present.

1.4 | Pressure transducer

Electronic external transducer, connected to the tubing via a pressure dome is the most frequently used in ICS standard urodynamic evaluation and all pressure parameters are based on this system. New microtip or air filled transducers have the advantage of no air bubbles in the fluid system or obstruction of measuring holes, but the results obtained with these systems are not entirely identical.[11] New studies should elucidate the magnitude of the differences and uncover practical methods to calibrate the clinical results with the alternative systems with the available reference values obtained with fluid filled systems.

1.5 | Solution infused

Saline solution is the commonly used fluid for bladder filling. When videourodynamics is performed, a contrast solution is added. Body temperature fluid and room temperature fluid do not differently affect bladder sensory thresholds and do not unequally provoke DO or LUT irritation[12,13] but forced diuresis (without external filling) does lead to a higher incidence of DO.[14]

The infusion rate is, by ICS good urodynamic practices, divided into Physiological filling rate—less than predicted maximum; calculated with body weight in kg divided by four expressed in mL/min; Non-physiologic filling rate; defined as filling rate greater than the predicted maximum filling rate.[1] A fill rate of 10% of anticipated capacity, based on voiding diary and PVR, per minute may be an acceptable rule of thumb to select the (non-physiologic) fill rate.[1–3]

1.6 | Patient position

The ICS standard position during cystometry is sitting upright or standing in all patients able to do. The initial resting pressures, if zeroed to the ICS reference, are 15-40 cmH2O (sitting) or 30-50 cmH2O (standing), both for the vesical as well as intrarectal pressure. In the supine position, the vesical pressure will be 5-20 cmH2O and the intrarectal pressure in an individual, usually somewhat higher as a consequence of this position.[15] By consequence the subtracted detrusor pressures are around zero. Small differences (< + or − 10 cmH2O) can be considered to be a result from differences in catheter tip position of both catheters inside the body and are therefore acceptable.

1.6.1 | Bladder sensation

During the exam verbal communication is maintained with the patient so he/she can give information about the bladder sensation. This is a subjective parameter. ICS has defined three points to be evaluated: First sensation of bladder filling—is the feeling the patient has, during filling cystometry, when he/she first becomes aware of the bladder filling. First desire to void—defined as the feeling, during filling cystometry, that would lead the patient to pass urine at the next convenient moment, but voiding can be delayed if necessary. Strong desire to void—is defined, during filling cystometry, as a persistent desire to void without the fear of leakage.[1,3] These definitions should be put in practice as follows: First Sensation should be separated from the sensations that the catheterization has caused, that usually diminishes after the first minutes; The patient is asked "Tell me when you become aware that the bladder is not empty anymore." Normal desire is (if no or little chronic post void residual exists) usually roughly associated with "average" FVC-BD volumes and can be asked as: "Tell me when you have the sensation that normally tells you go to the toilet, without any hurry. Strong desire is "the moment that you, without any pain, will not likely postpone the voiding any more, and or will visit the nearest restroom, eg, while shopping." Correlating the results of cystometry volume and sensations with FVC-BD may provide background information regarding day to day sensory findings and bladder volumes. Sensation volumes are "normally" occurring at respectively ±30 and 60% of capacity, and are also associated with the dysfunction.[16,17] Bladder sensation can be classified with the terms normal, absent, reduced, and increased sensations. Sensation is considered increased when the sensations, as described above, occur early, at relatively small volumes.[1] Bladder sensation can also be atypical, usually in patients with neurological abnormalities (not further discussed in this module).

1.6.2 | Bladder capacity during filling cystometry

Bladder capacity during filling cystometry is characterized by cystometric capacity and maximum cystometric capacity. Usually reported is capacity at strong desire which may be interpreted as maximum cystometric capacity that should be around 500 mL in women[16,17] and somewhat less in elderly men.[8] Filling of more than 800 mL is seldom useful.

Maximum anesthetic capacity; the volume to which the bladder can be filled under deep general or spinal anesthetic, without urinary leakage, is rarely reported in scientific literature but may be of relevance in (ketamine) interstitial cystitis.

Cystometry is apart from urinary tract infection and urethral lesion not associated with excessive risks. In persons with a spinal cord lesion, however, autonomic dysreflexia may occur; immediate emptying of the bladder is the remedy (further discussed in specific ICS module). After cystoplasty or myectomy of the detrusor there is an increased risk of rupture of reservoir and especially in these patients (but not exclusively) the bladder should not be filled far beyond the usual volumes.[18,19]

1.6.3 | Detrusor function

Detrusor function can be normal or overactive.[1] Normal detrusor function—allows bladder filling with little or no change in pressure. Detrusor overactivity—is characterized by phasic detrusor pressure increments, which may be spontaneous or provoked. Examples of provocative maneuvers: non-physiological fast, for example, 100 mL/min bladder filling, change of position, stress test, and washing hands.

Detrusor overactivity should be classified as neurogenic or idiopathic. Detrusor overactivity is a urodynamic diagnosis and clinical symptoms may be urgency, urgency and incontinence, or overactive bladder syndrome.[1,7] When detrusor overactivity is observed in a patient with a relevant neurologic abnormality (should be diagnosed based on history and clinical examination) the detrusor overactivity is neurogenic.

1.6.4 | Bladder compliance

Bladder compliance represents the relationship between change in bladder volume and change in detrusor pressure and shows the capacity of the detrusor to relax and to stretch to accommodate to volume increment. Also reduced compliance may result in frequent voiding.

The module "cystometry advanced" discusses abnormalities of sensation and or detrusor function abnormalities.

2 | CONCLUSION

The evidence with regard to clinical setting and cystometry technique, as well as for catheters and transducers type, infused solution, and patient position is presented with recommendations. Also the practice of determining bladder filling sensation and capacity and the basis of detrusor storage function diagnosis is educated and provides the evidence background for the practice of cystometry shown in the ICS teaching module slides-set and presentation.

3 | POTENTIAL CONFLICTS OF INTEREST

Dr. Rosier reports grants from T-doc, grants from MMS/Laborie, grants from Astellas, outside the submitted work; Dr. D'Ancona reports grants from Astellas, outside the submitted work; Dr. Gomes has nothing to disclose.

REFERENCES

1. Abrams P, Cardozo L, Fall M, et al. The standardisation of terminology of lower urinary tract function: report from the Standardisation Sub-committee of the International Continence Society. *Neurourol Urodyn*. 2002;21:167–178.
2. Schäfer W, Abrams P, Liao L, et al. Good urodynamic practices: uroflowmetry, filling cystometry, and pressure-flow studies. *Neurourol Urodyn*. 2002;21:261–274.
3. Rosier PFWM, Schaefer W, Lose G, et al. International continence society good urodynamic practices and terms 2016 (ICS-GUP2016): urodynamics, uroflowmetry, cystometry and pressure-Flow study. *Neurourol Urodynam*. 2016; In press.
4. Abrams P, ed. *Urodynamcis*. 2nd ed. London: Sringer; 1997:1.
5. Rosier PF, Giarenis I, Valentini FA, Wein A, Cardozo L. Do patients with symptoms and signs of lower urinary tract dysfunction need a urodynamic diagnosis? ICI-RS 2013. *Neurourol Urodyn*. 2014;33:581–586.
6. Winters JC, Dmochowski RR, Goldman HB, et al. Urodynamic studies in adults: AUA/SUFU guideline. *J Urol*. 2012;188: 2464–2472.
7. Haylen BT, de Ridder D, Freeman RM, et al. An International Urogynecological Association (IUGA)/International Continence Society (ICS) joint report on the terminology for female pelvic floor dysfunction. *Neurourol Urodyn*. 2010;29:4–20.
8. Liao L, Schaefer W. Quantitative quality control during urodynamic studies with TVRs for cystometry in men with lower urinary tract symptoms suggestive of benign prostatic hyperplasia. *Int Urol Nephrol*. 2014;46:1301–1308.
9. Hogan S, Gammie A, Abrams P. Urodynamic features and artefacts. *Neurourol Urodyn*. 2012;31:1104–1117.
10. Cho SY, Oh SJ. The clinical significance of rectal contractions that occur during urodynamic studies. *Neurourol Urodyn*. 2010;29: 418–423.
11. Cooper MA, Fletter PC, Zaszczurynski PJ, Damaser MS. Comparison of air-charged and waterfilled urodynamic pressure measurement catheters. *Neurourol Urodyn*. 2011; 30:329–334.
12. Gelhrich AP, Hill MJ, McWilliams GD, Larsen W, McCartin T. Comparison of urodynamic volume measurements using room and body temperature saline: a double-blinded randomized crossover study design. *Female Pelvic Med Reconstr Surg*. 2012;18:170–174.
13. Klevmark B. Natural pressure-volume curves and conventional cystometry. *Scand J Urol Nephrol Suppl*. 1999;201:1–4.
14. van Venrooij GE, Boon TA. Extensive urodynamic investigation: interaction among diuresis, detrusor instability, urethral relaxation, incontinence and complaints in women with a history of urge incontinence. *J Urol*. 1994;152:1535–1538.
15. Sullivan JG, Swithinbank L, Abrams P. Defining achievable standards in urodynamics—a prospective study of initial resting pressures. *Neurourol Urodyn*. 2012;31:535–540.
16. Mahfouz W, Al Afraa T, Campeau L, Corcos J. Normal urodynamic parameters in women. Part II—invasive urodynamics. *Int Urogynecol J*. 2012;23:269–277.
17. Wyndaele JJ. Normality in urodynamics studied in healthy adults. *J Urol*. 1999;161:899–902.
18. Blok BF, Al Zahrani A, Capolicchio JP, Bilodeau C, Corcos J. Post-augmentation bladder perforation during urodynamic investigation. *Neurourol Urodyn*. 2007;26:540–542.
19. Ehdaie B, Mason MD, Gray M, Peters CA, Corbett ST. Bladder perforation in augmentation cystoplasty during urodynamic investigation: a case report and review of the literature. *J Pediatr Urol*. 2013;9:102–106.

How to cite this article: D'Ancona CAL, Gomes MJ, Rosier PF. ICS teaching module: Cystometry (basic module). *Neurourology and Urodynamics*. 2017;36:1673–1676. https://doi.org/10.1002/nau.23181