URODYNAMICS

Purpose of this report

Urodynamic testing is an important tool in urogynecology providing objective descriptions concerning the patient's incontinence and voiding dysfunction. As technology advances and definitions are refined, it is important that clinicians providing urogynecologic care adhere to practices and principles that are evidence-based and to international standards and recommendations (Abrams P, Cardozo L et al. The Standardization of Terminology of Lower Urinary Tract Function: Report from the Standardization Sub-committee of the International Society. Neurourol Urodyn 2002; 21: 167).

Role of UD testing

The goal of urodynamic testing is to provide objective confirmation of the signs and symptoms of incontinence. While diagnosis and optimal treatment of lower urinary tract dysfunction (LUTD) requires a careful history and objective evaluation, it has been demonstrated that urinary symptoms are not specific in predicting the dysfunction of the patient's incontinence (Cundiff[1]; Drutz[2]; Cardozo[3]). The dilemma facing physicians treating urinary incontinence is that symptoms, patient questionnaires, physical examination findings, voiding diaries, and pad testing do not correlate well with the final diagnosis. UD testing must be interpreted in combination with other findings.

Naturally, there remains a level of uncertainty about the role of UD. Some feel that it is not cost effective and only helpful under certain circumstances. Others consider UD essential in assessing urinary incontinence to confirm definitive and objective diagnosis (Cantor 80[4], Wiskind 94[5], Digesu et al 03[6], Homma 03[7]) and have advocated its use in all patients prior to surgical intervention (Summitt et al 02[8]; Sand et al 88[9]; Korda et al 88[10], McGuire et al 76[11]). UD may also detect detrusor overactivity that may or may not be clinically relevant.

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[1] Cundiff GW, Harris RL, Coates KW, Bump RC. Clinical predictors of urinary incontinence in women. Am J Obstet Gynecol. 1997 Aug; 177(2):262-7.

[2] Drutz HP, Mandel F. Urodynamic analysis of urinary incontinence symptoms in women. Am J Obstet Gynecol 1979;122:789-92.

[3] Cardoza LD. Genuine stress incontinence and detrusor instability – a review of 200 patients. Br J Obstet Gynaecol 1980;87:184-90.

[4] Cantor TJ, Bates CP. A comparative study of symptoms and objective urodynamic findings in 214 incontinent women. Br J Obstet Gynaecol. 1980;87:889-892.

[5] Wiskind A

[6] Digesu GA, Salvatore, Cardozo L, Robinson D, Khulla V. Symptomatic diagnosis of the overactive bladder: is it helpful? Neurourol Urodyn.2000;19:381-2.

[7] Homma Y. The clinical significance of the urodynamic investigation in incontinence. BJU Int. 2002;90:489-97.

[8] Summitt RL, Stovall T, Bent AE, Ostergard DR. Urinary incontinence: correlation of history and brief office evaluation with multichannel urodynamic testing. Am J Obstet Gynecol 1992;166:1835-44.

[9] Sand PK, Hill RC, Ostergard DR. Incontinence history as a predictor of detrusor stability. Obstet Gynecol. 1988;71(2):257-60.

[10] Korda A, Drieger M, Hunter P, Parkin G. The value of clinical symptoms in the diagnosis of urinary incontinence in the female. Aust N Z Obstet Gynaecol 1987;27:149-51.

[11] McGuire EJ, Lytton B, Pepe V, Kohorn EI. Stress urinary incontinence. Obstet Gynecol. 1976;47:255.

Criticisms of UD testing, however are that universal testing limits access to specialty care, it does not lead to a clinically important improvement in the patient's condition, and the cost of a single additional cure is too costly.

Symptoms of urinary incontinence

Ideally, comprehensive preoperative evaluation under standardized conditions should correctly identify patients requiring medical versus surgical therapy. Unfortunately, a standardized approach to diagnosing patients with SUI or irritative complaints is lacking. Various parameters have been investigated in varied combinations including AHCRP guidelines (Fantl et al 96), positive stress tests (Handa[12], Videla 98[13]), urethral hypermobility (Handa, Diokno et al 99), maximum bladder capacity > 400 mL (Videla 98), residual < 50 mL (Handa, Videla 98), residual < 200 mL (Diokno et al 99), no previous surgery (Handa, Diokno et al 99, Lemack 2000[14]), age under 65 (Handa), and predominant stress incontinence by history (Fantl et al 96, Handa, Cundiff et al 97, Videla 98, Diokno et al 99, James, Lemack 2000).

According to the International Continence Society (2002) [15], lower urinary tract dysfunction should be defined by separate categories including symptoms (subjective indicator of the disease or a perceived change in the condition), signs (observations made by the physician), objective urodynamic observations, and conditions (presence of urodynamic observations associated with characteristic symptoms or signs).

Lemack (Lemack 2000) was able to demonstrate that some UD tests could be avoided thus, lowering cost, but could not be eliminated and provides clinicians with the most detailed information regarding the cause of the patient's incontinence. Videla and Wall (Videla 98) found that patients with a predominant complaint of stress incontinence, a positive cough stress-test, a post-void residual of < 50 mL, and a functional bladder capacity of at least 400 mL determined by a 24-hour frequency-volume chart were found to have GSUI in 97%. Firteen percent also had detrusor contractions. Other studies have demonstrated that the positive predictive value of presenting symptoms of SUI is 87% (Lagro-Janssen et al 91[16]) with a sensitivity of 65 – 100% and a specificity of 65 - 89% (Sand et al 87; Lagro-Janssen et al 91; Korda et al 87). High specificity is perhaps a more important test characteristic than high sensitivity since a high specificity corresponds to a lower false-positive rate. In other words, fewer patients would be wrongly identified as stress incontinent and potentially mistreated.

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[12] Handa V

[13] Videla F, Wall LL. Stress incontinence diagnosed without multichannel urodynamic studies. Obstet Gynecol 1998;91:965-8.

[14] Lemack GE, Zimmern PE. Identifying patients who require urodynamic testing before surgery for stress incontinence based on questionnaire information and surgical history. Urology. 2000;55:506-11.

[15] Abrams P, Cardozo L, Fall M, Griffiths D, Rosier P, Ulmsten U, van Kerrebroeck P, Victor A, Wein A. The standardization of terminology of lower urinary tract function: report from the standardization sub-committee of the International Continence Society. Am J Obstet Gynecol. July 2002; 187(1); 116-26.

[16] Lagro-Janssen ALM, Debruyne FMJ, Van Weel C. Value of the patient's case history in diagnosin urinary incontinence in general practice. Br J Urol 1991;67:569-72.

For detrusor instability, the patient's history is a poor predictor (Sand et al 87) while pure symptoms of GSUI and DI are insensitive predictors because they identify fewer than half of the patients (Cundiff et al 97). The positive predictive value for symptoms of OAB (frequency, urgency, and/or urge incontinence) is predictive of detrusor overactivity in 54% and therefore under-diagnosed OAB in this study. (Digesu et al 2000). It is suggested that all women with nocturia, nocturnal enuresis, urge incontinence or atypical incontinence should receive UD (Cantor and Bates 80).

In a comprehensive review, Jensen et al[17] reviewed 29 published studies and concluded that the patient's history was inadequate in providing an accurate diagnosis and could lead to a misdiagnosis in up to 25% of cases. Compared to an objective UD diagnosis, the specificity for SUI and detrusor overactivity were 0.51 and 0.55, respectively. A similar review by Homma (Homma 02) further illustrates the poor predictive value of the patient's history and symptoms. The patient's history and symptoms may not be predictive of the final diagnosis and should not be used as the sole determinant of diagnosis or treatment (Jensen). The patient's history is also a poor predictor of the underlying cause of incontinence based on the final objective urodynamic diagnosis. Basing treatment of incontinence on a history of urge loss results in a misdiagnosis in 45% of patients (Sand et al 88).

Many confounding factors may exist such as hypoestrogenism(Cundiff et al 97 urogenital atrophy, cognitive factors in the elderly[18], urethral hypermobility (Cundiff et al 97), and prolapse. The patient's history, symptoms, and objective UD results should be considered in light of these factors and others.

Urethral hypermobility

Bladder neck hypermobility is observed in both continent and incontinent women (Bergman et al 87)[19] yet is generally more pronounced in incontinent patients (Meyers et al 96[20] (Walters 87).[21] Urethral hypermobility is not an independent variable effecting frequency or severity of incontinence (Fleischmann et al 03)[22] and lacks sensitivity and specificity in diagnosing the type of incontinence (Shull et al 02).[23]

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[17] Jensen JK, Nielsen R, Ostergard DR. The role of patient history in the diagnosis of urinary incontinence. Obstet Gynecol. May 1994;83(5):904-910.

[18] Kirschner-Hermanns R, Scherr PA, Branch LG, Wetle T, Resnick NM. Accuracy of survey questions for geriatic urinary incontinence. J Urol. 1998;159:1903-8.

[19] Bergman A, McCarthy TA, Ballard CA, Yanai J. Role of the Q-tip test in evaluating stress urinary incontinence. J Reprod Med. 1987;32:273.

[20] Meyer S. De Grandi P, Schreyer A, Caccia G. The assessment of bladder neck position and mobility in continent nullipara, multipara, forceps-delivered and incontinent women using perineal ultrasound : a future office procedure? Int Urogyneol J Pelvic Floor Dysfunct. 1996;7:138.

[21] Walters MD, Diaz K. Q-tip test: a study of continent and incontinent women. Obstet Gynecol. 1987;70:208.

[22] Fleischmann N, Flisser AJ, Blaivas JG, Panagopoulos G. Sphincteric urinary incontinence: relationship of vesical leak point pressure, urethral mobility and severity of incontinence. J Urol. 2003;169:999-1002.

[23] Shull BL, Hurt G, Laycock J, Palmtag H, Youn Y, Zubieta R. Physical examination. In: Incontinence. 2nd International Consultation on Incontinence, Paris, July 1-3, 2001. Edited by F Abrams, L. Cardozo, S. Khoury and A. Wein. Plymouth, United Kingdom: Health Publication, Ltd., pp. 373-388, 2002.

Severity of incontinence: incontinence questionnaires, diaries, and pad tests

Incontinence severity has been defined using 24-hour urine pad tests to quantify urinary loss. At present, there is no consensus on how to grade the severity of incontinence. Slack et al 04[24] however, have proposed grading incontinence severity as mild (0 – 8 gm/24 hours), moderate (8.1-30 gm), and severe ($\geq$ 30 gm).

Voiding diaries enjoy widespread use. Unfortunately, studies confirming the role in diagnosing and treating urinary incontinence are lacking. James et al concluded in a study involving over 5,000 women that voiding diaries are not predictive of the final diagnosis. (James et al 99)[25]

Numerous patient questionnaires are used in assessing urinary incontinence symptoms. These include the incontinence quality of life (I-QOL), urinary incontinence severity score (UISS), the patient global impression of severity scale (PGI-S), and the incontinence visual analog score (VAS) among others. Symptoms scores and quality of life (QOL) measures lack correlation to UD measures and are inadequate predictors of urodynamic outcome. (Swift 95)[26] (Fitzgerald 02)[27] Nager et al were unable to find a correlation with UD parameters and both pad loss or QOL measures.[28] The Gaudenz-Incontinence-Questionnaire was found to have a low sensitivity (GSUI 56%, DI 62%) and specificity (GSUI 47%, DI 56%) when compared to objective UD measurements; too low to justify its use as a diagnostic tool. (Haeusler et al 95)[29]

Stress urinary incontinence

Stress urinary incontinence caused by problems with the urethral sphincter mechanism as well as with urethral support.[30] [31] A classic description of the continence mechanism is that of urethral compression. Imagine a garden hose being compressed on a hard surface. The flow of water is slowed or stopped. Similar compression of the hose sitting upon a trampoline will result in minimal compression of the hose and the flow of

[24] Slack M, Culligan P, Tracey M, Hunsicker K, Patel B, Sumeray M. Relationship of urethral retro-resistance pressure to urodynamic measurements and incontinence severity. Neurourol Urodyn. 2004;23:109-114.
[25] James M, Jackson S, Shepherd A, Abrams P. Pure stress leakage symptomatology: is it safe to discount detrusor instability? Br J Obstet Gynaecol. Dec 1999;106:1255-1258.
[26] Swift SE, Ostergard DR. A comparison of stress leak-point ressure and maximal urethral closure pressure in patients with genuine stress incontinence. Obstet Gynecol. 1995;85:704-8.
[27] Fitzgerald MP, Brubaker L. Urinary incontinence symptom scores and urodynamic diagnoses. Neurourol Urodyn. 2002;21:30-5.
[28] Nager CW, Schulz JA, Stanton SL, et al. Correlation of urethral closure pressure, leak-point pressure, and incontinence severity measures. Int Urogynecol J Pelvic Floor Dysfunct. 2001;12:395-400.
[29] Haeusler G, Hanzal E, Joura E, Sam C, Koelbl H. Differential diagnosis of detrusor instability and stress incontinence by patient history: The Gaudenz Incontinence questionnaire revisited. Acta Ostet Gynecol Scand 1995;74:635-7.
[30] Enhorning G. Simultaneous recording of intravesical and intraurethral pressure. A study on urethral closure in normal and stress incontinent women. Acta Chir Scand. 1961;276 suppl:1.
[31] Hodgkinson CP. Relationships of the female urethra and bladder in urinary stress incontinence. Am J Obstet Gynecol. 1953;65:560.

fluid will continue. [32] The pubovaginal sling controls SUI by mechanical compression of the urethra between the implant and the symphysis pubis.[33]

The symptom of SUI is defined by the ICS (Abrams 2002) as involuntary leakage on effort or exertion, or on sneezing or coughing. In 1968, Green[34] described 2 types of stress urinary incontinence based on the anatomical relationship of the urethra to the bladder base. These were categorized as Type I (loss of the posterior urethrovesical angle) and Type II (inferior and rotational descent of the bladder base and urethra). This was modified to include Type 0 (stress incontinence not reproducible in the clinical setting), Type IIB (urethra abnormally positioned at rest, such that incontinence ensures with little additional descent during stress[35] and Type III (McGuire et al 76) (the vesicourethral angle is not compromised and the proximal urethra fails to function as a competent sphincteric unit).

Mixed incontinence

Mixed incontinence is defined as involuntary leakage associated with urgency and also with exertion, effort, sneezing or coughing (Abrams 2002). Patients with persistent incontinence postoperative usually have persistent detrusor overactivity therefore medical therapy prior to surgical intervention is recommended unless advanced pelvic organ prolapse is diagnosed.[36]

Detrusor overactivity

Irritative bladder symptoms include urgency (sudden compelling desire to pass urine which is difficult to defer), overactive bladder (OAB), urge syndrome, or urgency-frequency syndrome. Other irritative bladder signs and symptoms include daytime frequency (the patient considers that they void too often by day), nocturia (the individual has to wake at night one or more times to void), urge urinary incontinence (involuntary leakage accompanied by or immediately preceded by urgency).

Urodynamics findings describe three main types of overactive bladder: uninhibited OAB (impaired perception of bladder fullness loss of involuntary inhibition of micturition); phasic detrusor instability (urgency with or without urge incontinence, normal or increased bladder sensation with phasic bladder contractions during filling); and, spinal detrusor hyper-reflexia. (Fall[37]) With aging an abnormal perception of bladder fullness and a lack of voluntary inhibitory control of a sustained detrusor

[32] Ashton-Miller JA, Howard D, DeLancey JOL. The functional anatomy of the female pelvic floor and stress continence control system. Scand J Urol Nephrol. 2001;207 suppl:1-7.
[33] Dietz JP, Wilson PD. The 'iris effect' : how two-dimensional and three-dimensional ultrasound can help us understand anti-incontinence procedures. Ultrasound Obstet Gynecol. 2004;23;267-72.
[34] Green TH Jr. The problem of stress urinary incontinence in the female: an appraisal of its current status. Obstet Gynecol Surv. 1968;23:603.
[35] Blaivas JG, Olsson CA. Stress incontinence: classification and surgical approach. J Urol. 1988;139:727-31.
[36] Karram MM, Bhatia NN. Management of coexistent stress and urge incontinence. Obstet Gynecol 1989;73:4-7.
[37] Fall M, Geirsson G, Lindstrom S. Toward a New Classification of Overactive Bladders. Neurourol Urodyn. 1995;14:635-646.

contraction, and a lowered micturition threshold may develop indicating a suprapontine dysfunction.[38] Diagnostic workup with neurologic examination, computerized tomography, and magnetic resonance imaging will likely remain normal although undetected vascular lesions may be seen.[39] Some patients with uninhibited OAB may maintain control of their external urethral sphincter and maintain continence despite their uncontrolled detrusor. A provocative test that may uncover increased sensitivity indicating upper motor neuron lesions is the ice-water test. (Geirsson et al 93). UD testing does not predict who will respond to treatment for OAB.[40] Perhaps tailored drug therapy using different pharmacologic agents that target the various types of irritative bladder dysfunction will prove more effective in the future.

Low pressure urethra

Low pressure urethra was first introduced by McGuire et al in 1981 as the detrusor leak point pressure (DLPP).[41] In patients with neurogenic bladder, a DLPP of > 40 cmH20 were more likely to develop upper tract damage secondary to increased urethral resistance. In 1993, McGuire introduced the abdominal leak point pressure (ALPP) as a measure urethral pressure. This UD measurement has been newly added to ICS terminology and is defined as the lowest detrusor pressure at which urine leakage occurs in the absence of either a detrusor contraction or increased abdominal pressure (Abrams et al 2003). Various values have been proposed using different techniques and bladder volumes. Currently, UD literature refers to LPP as <90 cm H2O. An LPP >90 cm H2O suggest that incontinence is anatomic and is associated with urethral hypermobility.[42] Another widely used measure of urethral sphincter function is the maximum urethral closure pressure (MUCP). Sand et al 88[43] proposed a cutoff value of ≤ 20 cm H2O since the cure rate for a Burch retropubic colposuspension was lower (46%) compared to patients with an MUCP of > 20 cm H2O (82%). This finding was only consistent in women over age 50.

A low ALPP or a low MUCP are often referred to intrinsic urethral sphincteric deficiency (ISD). The term ISD is not recognized as an objective UD diagnosis by the ICS. The MUCP appears to correlate with passive resting pressure of the urethra while the ALPP measures the active resistance (dynamic response).[44] Unfortunately, correlation between the MUCP and ALPP with symptom severity and treatment outcome is absent.

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[38] Giersson G, Fall M, Lindstrom S. Subtypes of overactive bladder in old age. Age and Ageing. 1993;22:125-31.

[39] Kitada S, Ikei Y, Hasui Y, et al. Bladder function in elderly males with subclinical brain MRI lesions. Neurourol Urodynam 1991;10:436-7.

[40] Wagg A, Bayliss M, Inghar NJ, Arnold K, Malone-Lee J. Urodynamic variables cannot be used to classify the severity of detrusor instability. Br J Urol 1998;82:499;502.

[41] McGuire EJ, Woodside JR, Borden TA, Weiss RM. Prognostic value of urodynamic testing in myelodysplastic patients. J Urol. 1981;126:205-9.

[42] Lane TM, Shah PJ. Leak-point pressures. BJU Int. 2000;86:942.

[43] Sand PK, Bowen LW, Panganiban R, et al. The low pressure urethra as a factor in failed retropubic urethropexy. Obstet Gynecol 1987;69:399-402.

[44] Hseih GC, Klutke JJ, Kobak WH. Low valsalva leak-point pressure and success of retropubic urethropexy. Int Urogynecol J. 2001;12:46-50.

Recently the urethral retro-resistance pressure (URP), a urethral measurement explored in the past,[45] [46] has experienced a resurgence. It represents a physiologic measure of urethral function and measures the pressure required to maintain an open sphincter. Unlike other urethral measurements, the URP decreased with increasing incontinence severity and appears to decrease with age (Slack et al).

The pressure transmission ratio (PTR) of less than 100% is consistent with the definition of GSUI. However, MUCP and PTR are not useful in reliably distinguishing between continent and incontinent women due to a large overlap in values.[47] [48]

Indications for urodynamic testing

Urodynamics is a clinical test or a series of clinical tests used to describe the current function or dysfunction of the lower urinary tract. In theory and in practice, the clinician utilizes the results of urodynamic testing to direct therapy whether surgical, medical or behavioral alone or in combination. Current methods include water filled UD, ambulatory UD, and videourodynamics. Regardless of the method, UD examines the functional anatomy of the bladder or urethra or both and their and their response to filling, storing, and voiding. Indications for UD testing are summarized in table 1.

Table 1
Recommendations for the Use of Urodynamics in Clinical Practice[49]

Urodynamics should be done in women if:	Invasive or surgical treatment is considered
	Previous treatment for incontinence (surgical or non-surgical) has failed
	Voiding difficulty or neuropathy is suspected
Other indications include:	Women over age 50 (Horbach)
	Complex symptoms (e.g. mixed symptoms) (Karram)
	Inconclusive single channel studies
	Nocturnal enuresis not responding to therapy
	Previous pelvic radiation or radical pelvic surgery
	Neurologic disorders
	Continuous leakage
	Suspected voiding dysfunction
	Prolapse stage III or IV (Veronikis)

[45] Bonney V. On diurnal incontinence of urine in women. J Obstet Gynaecol Br Emp. 1923;30:324.
[46] Bors E. A simple sphincterometer. J Urol. 1948;56:287.
[47] Bump RC, Copeland WE, Hurt WG, et al. Dynamic urethral pressure profilometry pressure transmission ratio determinations in stress-incontinent and stress-continent subjects. Am J Obstet Gynecol. 1988;159:749-55.
[48] Versi E, Cardozo LD, Cooper DJ. Urethral pressures: analysis of transmission pressure ratios. Br J Urol. 1991;68:266-70.
[49] Homma, Y., Batista, J., Bauer, S. et al. Urodynamics. In: Incontinence: 2nd International Consultation on Incontinence, Edited by P. Abrams, L. Cardozo, S. Khoury et al. Plymouth, United Kingdom: pp. 317, 2002

Cystometry

Cystometry (CMG) is the most accurate tool for evaluation of bladder function with filling. (Dmochowski 1996)[50] A positive cough stress test and single-channel cystometry may be the minimally accepted tests prior to intervention. (Summitt et al 92). Simple office based cystometry can be performed and may yield sufficient information to proceed with treatment. Complex single channel and multi-channel cystometry is available yet requires specialized, expensive equipment and training to properly interpret the findings. Advantages are that fluid-filled CMG allows determination of pressure related fluid loss, estimates leak pressures, and allows simultaneous measures of multiple variables.

Table 2
Standardized Multichannel Urodynamic Procedure (Lose 2002)

1) Urethral catheter is inserted 4-5 cm with the transducer in the 3 o'clock position and withdrawn until a rise in Pura is noted – proper placement of the dual-sensing catheter.

2) Vaginal catheter is inserted 3-5 cm into the vagina until minimally fluctuating Pabd measurements are seen.

3) Pabd and Pves should be equal or comparable at the start of the test.

4) Filling cystometry at 50-80 ml per minute, sterile solution at room temperature.

5) Document:
- First sensation
- Strong desire to void
- Urgency (max cystometric capacity; MCC)
- Any detrusor overactivity

6) MUCP x 3 at 100 ml and x 3 at MCC; pull rate of 1-4 mm per second

7) LPP x 3 at 250 ml – bearing down to reach a pressure of between 60 – 100 cm H2O.

8) Dynamic cough profile at MCC to detect SUI.

Voiding profiles

Griffiths et al 92 demonstrated that urinary production varies throughout the day and is increased at night. A simple voiding measure that should be performed on all patients with incontinence or voiding dysfunction is the post-void residual (PVR). Uroflowmetry measures flow time, flow rate, voided volume, and average flow rate. The clinical utility of uroflow measurements may be predictive of post-operative voided dysfunction. (ref)

[50] Dmochowski R. Urodynamics 1. Urol Clin North Am. 1996;23:???.

Urethral pressure profilometry

Urethral pressure is defined as the fluid pressure needed to just open a closed (collapsed) urethra.[51] UD measurements of the urethra quantify urethral length and pressures relative to the bladder and abdominal pressures as a means of quantifying the continence mechanism. Urethral pressure profilometry (UPP) are clinical tests that evaluate the functional status of the urethra in women measuring intraluminal pressure along the length of the urethra. Studies include maximum urethral closure pressure (MUCP), functional urethral length (FUL), and pressure transmission ratio (transmission index) (PTR), and leak point pressure (LPP). The MUCP measures the passive resistance (resting tone) of the urethral sphincter and is lower in women over age 50.[52] It is generally lower in incontinent women however there is a considerable overlap of measured values compared to continent women.[53] MUCP values in women with prior anti-incontinence surgery are typically lower.[54]

Urethral dysfunction cannot be reliably parsed and the sling procedure appears to work effectively for all types and severities of stress incontinence. Therefore, it has been suggested that the UPP is of little or no use.[55] [56] According to the ICS there is no urethral pressure measurement that discriminates urethral incompetence from other disorders, provides a measure of the severity of the condition or, provides a reliable indicator to surgical success.[57] Weber,[58] in a comprehensive review of the literature spanning 34 years concluded that due to the lack of standardization, urethral pressure profilometry is not a useful diagnostic tool for stress incontinence in women. The conclusion is that its use in clinical management is not supported by current evidence (Table 3) and many consider urethral pressure measurements to be a research tool.

[51] Griffiths D. The pressure within a collapsed tube, with special reference to urethral pressure. Phys Med iol. 1985;30:951-63.
[52] Rud T. Urethral pressure profile in continence women from childhood to old age. Acta Obstet Gynecol Scand. 1980;59:331-5.
[53] Versi E, Cardozo LD, Studd J et al. Evaluation of urethral pressure profilometry for the diagnosis of genuine stress incontinence. World J Urol 1986;4:6-9.
[54] McGuire EJ. Urodynamic findings in patients after failure of stress incontinence operations. Prog Clin Biol Res 1981;78:351-60.
[55] Appell RA. Primary slings for everyone with genuine stress incontinence ? The argument for. In Urogynecol J Pelvic Floor Dysfunct. 1998;9:249-51.
[56] Leach, E, Dmochowski RR, Appell RA, Blaivas JG, Hadley HR, Luber KM, et al. Female stress urinary incontinence clinical guidelines panel: report on the surgical management of female stress urinary incontinence. Presented at American Urological Association Female Stress Urinary Incontinence Clinical Guidelines Panel, 1997.
[57] Lose G, Griffiths D, Hosker G, Kulseng-Hanssen S, Perucchini D, Schafer W, Thind P, Versi E. Standardisation of urethral pressure measurement: report from the standardization sub-committee of the international continence society. Neurourol Urodyn. 2002;21:258-60.
[58] Weber AM. Is urethral pressure profilometry a useful diagnostic test fo rstress urinary incontinence? Obstet Gynecol Surv. 2001;56(11):720-35.

Table 3

UPP measures may be affected by:	-Catheter size, rigidity, orientation in the urethra, balloon size
	-Patient position[59] [60] or movement
	-Different perfusion systems and mediums
	-Presence of pelvic organ prolapse
	-Type of device used to reduce pelvic organ prolapse
	-Body mass index
	-Age
	-Bladder volume[61]
UPP is not clinically useful due to:	-Poor reproducibility (84%) therefore multiple attempts are suggested (Cundiff)
	-Minimal changes in profile pressures and FUL after anti-incontinence surgery (Henrikssen, Bump)
	-Large range and overlap of values make MUCP and PTR useless in reliably distinguishing between continent and incontinent women. (ref)
	-PTR not useful in diagnosing SUI (Versi)
	-UPP does not meet the criteria for a useful diagnostic test. (Vereeken[62])
	-No correlation between MUCP and LPP with symptom severity. (Slack et al)

Provocative measures

Certain provocative maneuvers may improve the diagnostic accuracy of certain tests of bladder and urethral function. Petros and Ulmsten used 163 provocative hand washing to produce a decrease in urethral pressure immediately followed by urge symptoms and preceded an unstable detrusor contraction. A good explanation of why surgical treatment directed at the bladder outlet produces resolution of detrusor instability in some patients.[63]

During cystometrogram, the ice-water test may be positive in up to 75% of patients with upper motor neuron pathology such as multiple sclerosis, Parkinson's

[59] Henriksson L, Ulmsten U, Andersson KE. The effect of changes of posture on the urethral closure pressure in healthy women. Scand J Urol Nephrol 1977;11:201-6.
[60] Lose G. Impact of changes in posture and bladder filling on the mechanical properties of the urethra in healthy and stress incontinent females. Neurourol Urodyn 1990;9:459-69.
[61] Kujansuu E, Kauppila A. Urodynamic in female stress incontinence of urine: Diagnostic and pathophysiological aspects. Arch Gynecol. 1981;231:23-32.
[62] Vereecken RL. A critical view on the value of urodynamics in non-neurogenic incontinence in women. Int Urogynecol J Pelvic Floor Dysfunct 2000;11:188-195.
[63] Petros PE, Ulmsten U. Bladder instability in women: a premature activation of the micturition reflex. Neurourol Urodyn 1993;87:893.

disease, or prior cerebrovascular accident.[64] Patients with lower motor neuron lesions or SUI will not respond to the ice-water provocation.

The ICS has recently added bladder and pelvic pain syndromes to their terminology. The most common cause of pain of bladder origin is interstitial cystitis (IC) [65] with or without other detrusor overactivity. The recently developed pelvic pain/urgency/frequency (PUF) questionnaire is very useful in screening patients who have pelvic pain of bladder origin. In selected patients, the potassium sensitivity test (PST) can be used to confirm the diagnosis of pain of bladder origin.[66]

Prolapse

It is argued that 36-80% of women with advanced prolapse have potential incontinence; an argument for the use of urodynamics prior to surgery.[67] Reduction of prolapse to uncover potential (occult or latent) incontinence masked by the prolapse is imperative.[68] [69] [70] [71] [72] Various techniques have been employed including pessaries,[73] [74] rectal swabs (Veronikis), and Graves or Sims speculums.[75]

Outcomes and UD testing

Urodynamic testing may include simple or complex measurements of bladder and urethral function. Other measurements that serve a role in the diagnosis and treatment of patients with LUTD may include measures of post-void residual, symptom

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questionnaires, and provocative measures to refine the diagnosis. It is clear that the treatment of women with urinary incontinence requires a comprehensive workup that includes office-based screening and confirmatory testing. Despite well deserved criticisms, UD offers a confirmatory diagnosis and allows for a more rational approach to treatment (Homma) and is generally regarded as an essential part of the workup of any patient with urinary incontinence (Cardozo, Homma 02, Korda et al 87). This concept is arguable due to the lack of outcomes data demonstrating the UD was predictive of outcome (Weber)

Patients with SUI as the dominant symptom will likely demonstrate GSUI on UD testing. It is known that symptoms, physical examination, questionnaires and other office-based screening do not consistently reveal a final diagnosis. And, when only symptom-based treatments are considered, outcome is poorer in incontinent women.[76] Therefore, current standards suggest that patients with complicated pathophysiology should undergo UD prior to treatment, particularly surgical treatment. (Table 4).

Whether UD is predictive of outcome is one of continued debate. Patients treated non-surgically with physiotherapy showed no difference in treatment success rates based on whether they received urodynamic testing. However, the success rates were under 60%.[77] [78] Perhaps the question is not whether UD has a role but whether physiotherapy is warranted.

Patient factors such as estrogen status should be considered as well. Thompson et al questioned the role of UD in SUI and found that in women <50 years urodynamic evaluation was not predictive of outcome.[79]

The appropriate question is not whether UD predicts outcome. Instead, the lack of outcomes data may be offset by avoiding adverse outcomes from ill chosen treatment. It has been argued for over 30 years that without some form of objective urodynamic assessment, some patients will be subjected to unnecessary or ineffective surgery.[80] Jarvis et al[81] showed that the clinical diagnosis was over-diagnostic of detrusor instability and under-diagnostic GSUI confirmed by UD testing. In their study, 11 women would have undergone unnecessary bladder neck surgery.

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Not only does UD have a role is choosing surgery as a treatment option it provides information necessary to select treatments to consider and those to avoid. It allows counseling of the patient of the potential risks and pitfalls of surgery. The complications of incontinence surgery are to be considered in every patient (hemorrhage, hematoma, bladder injury, urinary tract injury, urinary retention, failed surgery, and post-operative urinary dysfunction).[82] The pelvic surgeon has several surgical options from which to choose. Anti-incontinence procedures may be performed vaginally, abdominally, laparoscopically, or via combined routes. The surgeon may choose to use traditional approaches or may use newer modified techniques that employ biologic or synthetic graft materials. Unfortunately, there is no standardization in surgical approaches.[83] (Blaivas and Olesson) In fact, advances in surgical equipment, devices, and techniques are proceeding without supporting outcomes data.

The surgical approach to GSUI lacks standardization and is treated with many varied procedures.[84] [85] Retropubic colposuspension offers a cure rate of up to 90%[86] with 95% success reported after a pubovaginal sling for SUI.[87] Similarly high success rates are seen in with mixed incontinence (Osman). Surgeons who prefer an abdominal or laparoscopic retropubic colposuspension technique, would predictably have higher failure rates if low urethral pressures are not uncovered during UD. These patients would be predicted to demonstrate higher continence rates if treated with a pubovaginal sling procedure.[88] [89]

Post-operative voiding function is predictably worse when pre-operative voiding difficulties exist.[90] Pre-operative UD measurements showing voiding abnormalities such as Valsalva voiding or low flow rates may predict abnormal symptomatic voiding dysfunction post-operatively.[91]

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Patient satisfaction rates are lower in women who develop detrusor overactivity post-operatively[92] (Colombo 96). Therefore, the question of detrusor activity pre- and post-operatively is of importance. It is known that up to 20% of women may develop de novo detrusor overactivity post-operatively.[93] [94] This effect is more pronounced after a pubovaginal sling (17%) compared to a retropubic colposuspension (5%).[95] Pre-operative urgency and urge incontinence may subside after incontinence surgery[96] perhaps by diminishing the facilitative reflex.[97] Fulford et al (Fulford) reported that post-operative urgency was not associated with pre-operative clinical or urodynamic variables. However, complete resolution of urge symptoms is reported in 54 (DeMarco et al) - 59% (Columbo 96). Detrusor contractions may be seen in normal asymptomatic volunteers[98] however patients undergoing anti-incontinence surgery who have preexisting detrusor overactivity report less favorable outcomes.[99] It appears that patients with sensory or high pressure motor urge on preoperative urodynamic evaluation may identify those at high risk for persistent urgency postoperatively.[100] Patients with low urethral pressures may demonstrate detrusor overactivity after surgical correction and may go undetected until urethral pressure is restored.[101] Therefore, UD testing plays an important role in predicting post-operative detrusor function.

Conclusions

UD has a significant role in urogynecology and female pelvic medicine. It is argued that UD testing is not cost effective, limits access to specialty care, requires specialized and expensive equipment, special training, and interpretation skills.[102] It is difficult and perhaps, not appropriate to recommend universal testing in all patients however when considering the most common forms of urinary incontinence, UD testing, despite certain limitations, continues to be the gold standard to define the pathophysiology of lower urinary tract dysfunction. It is proposed that UD is not necessary when straight forward SUI is the clinical diagnosis. Unfortunately, misdiagnosis with the potential for improper treatment is possible. The effects of

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unnecessary or inappropriate surgery, prolonged ineffective medical treatment, recurrent or persistent incontinence particularly if a less effective surgery has been done, and post-operative voiding dysfunction can lead to prolonged patient suffering with potential medicolegal ramifications.

Symptoms, questionnaires, voiding diaries, physical examination, and pad testing are not predictive of the final diagnosis and may lead to misdiagnosis. UD testing is considered by some to be an essential component of the workup of the incontinent patient. It is difficult to predict outcomes of anti-incontinence treatments when standardization is proposed but not adopted for patient workup, UD testing, or treatment of the incontinent woman. Outcomes based research under standardized conditions is needed.

Table 4

Based on ICS terminology (Abrams 2002)

Confirmed by UD	Not confirmed by UD
Detrusor overactivity incontinence	Increased daytime frequency
Neurogenic detrusor overactivity	Nocturia
Idiopathic detrusor overactivity	Enuresis
Stress urinary incontinence	Nocturnal enuresis
Urge incontinence	Other types of incontinence
Mixed incontinence	Symptoms associated with intercourse
Continuous incontinence	Pain syndromes
Hesitancy	
Straining	
Incomplete emptying	
Symptomatic pelvic organ prolapse	
Bladder pain with filling	
Pelvic pain of bladder origin	
Urgency	
Bladder compliance	
Bladder capacity	
Maximum cystometric capacity	
Urethral relaxation	
Urethral pressure	
Functional urethral length	
Pressure transmission ratio	
Abdominal leak point pressure	
Urinary flow rate and time	
Urinary voided volume	
Detrusor function during voiding	