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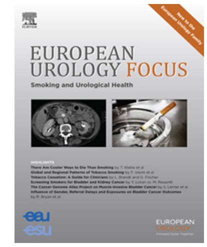

Review – Female Urology – Incontinence

Evaluation and Classification of Stress Urinary Incontinence: Current Concepts and Future Directions

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Abstract

Context: Stress urinary incontinence (SUI) is a common and bothersome problem that frequently requires operative management. Over the past two decades, novel techniques have been introduced into clinical practice. With the greater variety of surgical options now available, there is an increasing focus on selecting the appropriate procedure for the individual patient based on the likely underlying pathophysiologic mechanism.
Objective: To review the methods used in the evaluation of SUI and the proposed classification systems.
Evidence acquisition: A search of the PubMed database for the relevant search terms was conducted, and selected articles were retrieved and reviewed.
Evidence synthesis: Standardised terminology for the description of SUI has been produced by the International Continence Society describing the problem in terms of symptoms, clinical signs, and urodynamic observations. The two major pathophysiologic theories that have emerged over the past 50 yr, urethral hypermobility and intrinsic sphincteric deficiency, have influenced the development and adoption of surgical techniques. It is now recognised that these two entities are not dichotomous but often coexist. The primary aim of the evaluation of the patient presenting with SUI is to confirm the diagnosis and assess symptom severity before instituting conservative treatments. Secondary evaluation consists of more sophisticated techniques that assess anatomy of the bladder neck and urethra under rest and stress (eg, videourodynamics, ultrasound) or direct or indirect physiologic measures of the integrity of the sphincter mechanism.
Conclusions: Classification of patients with SUI into distinct groups based on probable pathophysiologic mechanism could help guide the choice of surgical procedure, but current systems are likely too simplistic, and methods of assessment lack standardisation in techniques and sensitivity.
Patient summary: Urinary leakage on exertion, termed *stress incontinence*, is a common problem that affects many women. There is a need to develop better ways of categorising the underlying causes of leakage to ensure that patients receive the optimal treatments.

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1. Introduction

Stress urinary incontinence (SUI) is an age-old problem that continues to generate great interest due to its considerable public health burden and the controversies that surround its management. It has been defined by the International Continence Society (ICS) as "the involuntary leakage of urine on exertion, or sneezing or coughing" [1]. The reported prevalence varies considerably due to inconsistencies in definitions and survey methods. One of the most thorough reviews (5th International Consultation on Incontinence) summarised that 10% of all women experience urine leakage at least weekly, whereas 25–45% have occasional leakage with SUI accounting for 50% of all incontinence [2]. A recent study utilising different survey methods confirmed this high prevalence [3]. In economic terms this translates to significant costs with an estimated annual direct cost of $13.12 billion in the United States [4], mostly due to the purchase of containment products and primary care visits. Given the trends in population growth and changing age demographics, costs are forecast to increase substantially over the next 20 yr [5]. Although generally perceived not to be as bothersome as urgency urinary incontinence [6,7], SUI exerts a significant personal burden on patients and is an important predictor of anxiety and depression [8].

In the past two decades, new techniques have been added to the SUI surgical armamentarium, in particular the less invasive midurethral tape procedures. The rate of SUI surgery has thus increased by as much as 27% [9]. Surgical management is associated with an incidence of treatment failure as well as a risk of potentially serious complications as has been well publicised. Consequently there is an increasing focus on identifying the right technique for the individual patient [10]. The diagnostic evaluation and classification of SUI is key to this process as well as the interpretation and comparison of data concerning the efficacy of different surgical approaches. This article reviews the contemporary basis for the evaluation of SUI and current classification systems with reference to relevant pathophysiologic concepts.

2. Evidence acquisition

A search of the PubMed database was conducted for full-text manuscripts in the English language using these search terms: stress urinary incontinence, evaluation, diagnosis, classification, urodynamics, videourodynamics, pressure-flow studies, cystometry, intrinsic sphincter deficiency, and urethral hypermobility. Abstracts were assessed for relevance and selected articles were reviewed. At least two authors checked the references used.

3. Evidence synthesis

3.1. Terminology

The importance of using appropriate terminology in the field of continence is widely recognised. In 2002, the ICS standardisation of terminology document described a rational approach to lower urinary tract dysfunction that categorises problems on the basis of symptoms as described by the patient, clinical signs as elicited by the clinician, and urodynamic observations [11]. The symptom of SUI is defined as the involuntary leakage of urine on exertion, sneezing, or coughing [11]. The sign of SUI is the observation of involuntary leakage from the urethra, synchronous with exertion/effort or sneezing or coughing [11]. Leakage must be observed immediately after the cough because cough-induced detrusor overactivity leakage may also occur following a short delay. SUI on prolapse reduction refers to the sign of stress incontinence only observed after the reduction of a coexistent pelvic organ prolapse. The urodynamic observation of SUI is termed *urodynamic stress incontinence* and characterised by the involuntary leakage of urine, associated with increased intra-abdominal pressure, in the absence of a detrusor contraction [11].

3.2. Pathophysiologic basis of stress urinary incontinence

An understanding of the pathophysiologic mechanisms that are postulated to cause SUI is essential to accurate classification. To date, these mechanisms are incompletely elucidated. Broadly two mechanisms are proposed: weakness in the supporting tissues of the urethra resulting in "urethral hypermobility" or a defective urethral sphincter mechanism termed *intrinsic sphincter deficiency* (ISD). These mechanisms are not dichotomous but rather represent a continuum, with many patients having features of both [12].

In 1923, Victor Bonney introduced the concept that SUI results as a consequence of loss in urethral support based on his observation of abnormal downward displacement of the anterior vaginal wall in women with SUI [13]. Following the work of others, Enhörning in 1961 introduced the pressure transmission theory, postulating that stress causes descent of the urethra out of the pelvis due inadequate proximal urethral support leading to a lack of transmission of intra-abdominal pressure to the urethra and thus causing urine leakage [14]. On this basis, retropubic suspension procedures to elevate the bladder neck and proximal urethra were popularised.

In the early 1990s, Delancey proposed the hammock theory based on studies on cadavers that demonstrated the urethra rests on the fused layers of endopelvic and pubocervical fascia attached to the arcus tendineus fascia pelvis and levator ani [15]. These fused layers are said to provide a hammock of support, a stable backstop against which the urethra is compressed during increases in intra-abdominal pressure. Around the same time, Petros and Ulmsten put forward a more complex mechanism focussed on laxity in the vaginal wall and pubourethral ligaments that they termed the integral theory [16]. The vagina is considered as suspended between the pubourethral ligaments anteriorly and the uterosacral ligaments posteriorly. During rest, the opposing forces of the pubococcygeus (anteriorly), levator plate (posteriorly), and longitudinal muscle of the anus (inferiorly) act in combination to pull the vagina taut. During stress the pubococcygeus muscle actively contracts, pulling the vaginal hammock around the urethra, immobilising and closing it. Simultaneously the levator plate and longitudinal muscle of the anus act in unison to pull the bladder base inferiorly and posteriorly, resulting in the urethra kinking in a plane around the pubourethral ligaments. When there is laxity in the anterior vaginal wall and pubourethral ligaments, the pubococcygeus is unable to compensate, resulting in failure of urethral closure and SUI.

The concept of ISD, a defective urethral sphincter mechanism as a distinct cause of SUI, was introduced by Edward McGuire in the 1970s and represented a major refinement in thought. McGuire based his theory on videourodynamic findings in women who had persistent SUI despite retropubic suspension procedures [17]. These women had a low proximal urethral closing pressure at rest with minimal or no urethral descent during stress. ISD may result from direct injury to the urethral sphincter or its somatic or autonomic innervation. Recognised causes include ischaemic compression during parturition, peripheral nerve injury, sacral spinal cord injury, radiation, and urethral surgery.

3.3. *Clinical assessment*

The aim of the assessment of a woman presenting with SUI is to confirm the diagnosis, assess symptom severity, and attempt to understand the underlying pathophysiologic mechanism, as to identify treatment options and risks. Recommendations about which tests to perform in the evaluation and in which context were previously published by the European Association of Urology [18].

3.3.1. *Primary evaluation*

The primary evaluation encompasses clinical history, voiding diary, physical examination, and postvoid residual estimation. The clinical history provides insight as to factors that precipitate leakage, as well as frequency and degree of leakage, and associated bother. ISD is typically associated with more severe leakage, and less provocation is required to trigger leakage, such that relatively minor movements, such as standing, can cause leakage. Details of previous obstetric, gynaecologic, or urologic interventions should be noted in addition to any neurologic symptomatology. Patients with ISD are more likely to have had prior urogenital surgery [19]. Validated questionnaires, such as the modified Incontinence Impact Questionnaire and the Urogenital Distress Inventory, may be helpful in categorising symptoms and determining severity of symptoms and associated bother. In routine practice, however, it is often the case that bother is assessed by asking the patient the direct question of how much symptoms affect her daily life and whether this bother is sufficiently severe for her to wish to undergo treatment, particularly invasive intervention.

The voiding diary is an essential adjunct to history taking, providing an objective measure of frequency and volume of leakage episodes [20]. For the clinician, the diary offers an indication of functional bladder capacity (usually 300–600 ml) and confirms the severity of symptoms. It also allows for a more objective assessment of fluid intake pattern [20] that may allow patients to realise adverse drinking habits [20]. The usual format involves the patient recording the times of voids, voided volumes, and incontinence episodes over a 24-h period for a minimum period of 3 d, with a record of fluid intake in terms of volume and type (eg, cup of tea). Shorter diaries are generally associated with better compliance and so may be more accurate than their longer counterparts [21].

Pad testing is a measure of the severity of incontinence but does not distinguish between types of incontinence. The patient wears an incontinence pad that is weighed before and after use to estimate how much the patient has leaked. It is particularly useful in proving the presence of incontinence when not demonstrable by other means [22]. Different tests have been described, varying mainly by the length of time the pad is worn.

The 1-h pad test, recommended by the ICS, involves the patient drinking 500 ml of fluid and within 15 min undertaking a series of standardised exercises lasting 1 h [23]. These exercises include (1) standing up from sitting 10 times, (2) coughing vigorously 10 times, (3) running in place for 1 min, (4) bending to pick up a small object from the floor five times, and (5) washing hands in running water for 1 min. An increase in pad weight $\geq$1 g is considered diagnostic [24].

Pad testing may also be conducted over longer lengths of time to provide a more realistic picture of severity of incontinence in everyday life. Pads are collected in resealable bags before being weighed, with an overall increase $>$8 g considered diagnostic [25]. A limitation of the test is that the change in weight of the pad(s) may be accounted for by increased vaginal secretions or sweating.

Although most would agree that clinical examination is an essential part of the evaluation of a patient with SUI, the precise components are not universally agreed upon. The primary aim is to demonstrate the presence of SUI through provocation manoeuvres and evaluate urethral mobility, in addition to assessments of coexistent pelvic organ prolapse, pelvic floor muscle strength and innervation, and the epithelial lining of the vagina.

SUI is usually elicited through the performance of the cough test, with the patient supine. Position can be changed if necessary (eg, squatting), or alternatively an activity that triggers leakage can be performed (eg, jogging, jumping). A cotton swab test was undertaken historically to assess urethral mobility and is abnormal if a $>30^\circ$ change occurs on straining [26]. Its reliability varies due to factors such as improper placement of the cotton swab into the urethra, and the cut-off of 30° to define hypermobility is somewhat arbitrary. Anecdotal evidence suggests that in contemporary clinical practice this test is infrequently performed, with some clinicians using it only in women undergoing surgery or alternatively in the setting of clinical research. Nevertheless, there is no clear evidence that a particular form of treatment should be recommended on the basis of the cotton swab test angle.

A coexistent pelvic organ prolapse should always be reduced to assess whether occult SUI is present, and it should also be assessed and quantified using an accepted approach such as the pelvic organ prolapse quantification system [27].

3.3.2. Secondary evaluation

Whether a urodynamic assessment should be performed in women with symptoms consistent with pure SUI prior to surgery has been hotly debated in recent years with the publication of three noninferiority randomised studies showing no difference in surgical outcomes whether patients underwent urodynamics or not [28–31]. Both sides of the argument have been represented in detail elsewhere in this journal [32,33], and we refer interested readers to these articles for a detailed analysis of the arguments made by each side of the debate. It is certainly widely accepted that the diagnosis of SUI can in most cases be reliably established with a good clinical history and physical examination. In clinical practice, urodynamics are usually reserved for situations where conservative measures have failed and the clinician seeks either to confirm the diagnosis in cases of doubt or answer questions to guide the choice of surgical technique, determine the presence of factors that may affect treatment outcome, and guide patient counselling. In the case of the complex patient (eg, previous surgical treatment failure, prior pelvic irradiation), most would agree that urodynamic evaluation is essential.

In the presence of convincing evidence of significant urethral hypermobility, some surgeons suggest a procedure to elevate the bladder neck such as a Birch colposuspension. Conversely, if urodynamic evaluation suggests significant ISD, an autologous fascial sling or artificial urinary sphincter may be considered. In current practice, such treatment decisions very much depend on individual surgeon preference and patient choice. In the context of urodynamics, these three urodynamic questions are often posed: (1) Is the underlying cause predominantly urethral hypermobility or ISD or a combination? (2) Is there coexistent bladder dysfunction, such as detrusor overactivity or reduced compliance, that is contributing to leakage? (3) Is there any evidence of bladder outlet obstruction or detrusor underactivity that may increase the risk of postoperative urinary retention?

The available scientific evidence for individual aspects of urodynamic assessment as predictors of surgical outcome could be considered dubious at best. The literature is mostly composed of observational studies with variation in urodynamic techniques, definitions of success, and length of follow-up, making it difficult to derive meaningful conclusions. Preoperative detrusor overactivity has been correlated with the development of postoperative urgency urinary incontinence with some consistency, as well as poorer outcomes [34,35]. The evidence concerning voiding parameters is less clear, partly attributable to the fact that bladder outlet obstruction and detrusor underactivity lack accepted diagnostic criteria in women. A raised postvoid residual >100 ml [36] and preoperative straining to void [37] were found to be associated with postoperative retention. Reduced maximal flow rate or low voiding pressure is not consistently associated with postoperative voiding dysfunction [38–41].

3.4. *Classification of stress urinary incontinence*

The aim of sphincteric evaluation is to determine whether the predominant problem is urethral hypermobility, ISD, or a combination of the two. Based on this, the choice of surgical technique can be made. Several methods are described, all of which have inherent limitations; consequently, there is no gold standard test.

3.4.1. Videourodynamics

The traditional approach is cystometry with synchronous videofluoroscopy (videourodynamics) that provides an anatomic perspective. The finding of excessive downward movement of the bladder neck and rotation of the urethra on straining indicate urethral hypermobility; in addition, loss of the normal posterior urethrovesical angle (90–100°), so that the base of the bladder and the urethra are in line, and funnelling of the urethrovesical junction (UVJ) are relevant observations. When leakage occurs in the absence of such movement, this infers significant ISD.

Over the past six decades, several videourodynamic classification systems were introduced into clinical practice. The first formal classification system for incontinence was introduced by Green in 1961, who described two types of SUI based on the finding of urethral hypermobility. Type I consisted of stress leakage with loss of the posterior urethrovesical angle, and in type II there was additional rotational descent of the urethra [42].

Green's classification remained the only system in place until it was modified by McGuire with the addition of type III incontinence that consists of an open bladder neck at rest associated with a low urethral pressure. This has become regarded as synonymous with ISD. Subsequently it was shown that treating patients with type III SUI with retropubic suspension led to poorer outcomes as compared with pubovaginal slings [43].

Blaivas and Olsson further modified the system with the addition of type 0 SUI and dividing type II SUI into two categories [44]. Type 0 consists of a patient who presents with a complaint of SUI and rotational descent of the urethra is present, but stress leakage cannot be demonstrated during a urodynamic study. Rotational descent of the urethra on stress is the key finding in type II SUI. In type IIa, the bladder base lies above the pubis at rest; in type IIb, the bladder base rests below the pubis.

Although the Green/McGuire/Blaivas classifications provided a logical system on which to base surgical decision making, it is important to recognise that the hypermobile urethra may also exhibit ISD that may not be apparent on fluoroscopy, a major limitation of videourodynamic classification. In addition, specialised equipment is required, and patients are exposed to radiation. Consequently, although often performed in specialised units, the test is not the standard approach in routine practice.

3.4.2. Ultrasound

Perineal ultrasound has been used to evaluate urethral hypermobility. It is usually performed with a 3.5- to 5-MHz curved probe placed on the perineum between the labia and allows direct visualisation of the urethra, UVJ, and bladder. The fixed landmark usually used to measure the position and mobility of the UVJ is the symphysis pubis. Bladder-neck mobility is described by two methods in which the symphysis is a fixed point and bladder-neck mobility is measured from this point during rest and Valsalva. Bladder-neck mobility can be described as the downward displacement of the UVJ (in millimetres) or a change in the retrovesical angle [45,46]. Ultrasound has clear attractions because it is noninvasive, widely available, radiation free, and relatively straightforward to perform. However it has low predictive value for SUI, and a large overlap exists between measures of urethral mobility in continent [47,48] and incontinent patients. As such it has not been adopted in routine practice.

3.4.3. *Urethral pressure profilometry*

Urethral pressure profilometry (UPP) is a method of obtaining pressure measurements along the length of the urethra using a fluid-filled catheter or catheter-mounted microtransducer. The most commonly studied parameter is the maximal urethral closure pressure (MUCP), the maximum pressure in the urethra minus bladder pressure, and hence theoretically represents the ability of the urethra to prevent leakage. MUCP is generally lower in incontinent women and decreases with ageing; however, there is a significant overlap of measured values compared with continent women [49,50]. UPP is known to be influenced by several parameters including type of catheter (fluid filled, microtip), catheter weight and stiffness, patient posture, and pelvic floor activity. There is conflicting evidence of whether low MUCP values in women can predict failure after retropubic suspension procedures [43,51–53]. Thus a cut-off MUCP value to predict ISD reliably has not become established. UPP is a technically demanding test with a great deal of variability in its reproducibility, and no conclusive evidence is available to support its use. Consequently the test has largely fallen out of favour in clinical practice.

3.4.4. *Leak-point pressure*

The Valsalva leak-point pressure, or abdominal leak-point pressure (ALPP), is a measure of the ability of the sphincter to close and coapt during increases in intra-abdominal pressure. It is defined as "the intravesical pressure at which urine leakage occurs due to increased intra-abdominal pressure in the absence of a detrusor contraction" [54]. The overall assumption is that the lower the leak-point pressure, the weaker the urethral sphincter and the more severe the stress incontinence. Several factors are known to influence the results, such as the catheter size and bladder volume at leakage, and there is a lack of standardisation on these points.

Although the ICS has produced a limited set of recommendations on good urodynamic practice with regard to ALPP [49], there is variation in the way the test is performed in the literature, making it difficult to compare data. Most studies suggest ALPP values correspond to the severity of incontinence symptoms and pad testing, although some reports contradict this. Lower values (typically <60 cm H_2O) are commonly used as an indication of ISD, which became established as the threshold when US Medicare regulations required its measurement for coverage for injection of periurethral bulking agents. Leakage at a high value (Valsalva leak-point pressure >90 cm) is used as an indication of urethral hypermobility.

A lack of good data supports these thresholds, and several studies have demonstrated low-level agreement between ALPP and MUCP, which could be explained by the large inaccuracy introduced when the investigator attempts to correlate the precise moment of leakage to the precise point on the upslope in abdominal pressure. As with UPP, further standardisation of methods and validation of thresholds are required, and the current evidence does not support the routine use of ALPP in clinical practice.

3.5. *Newer methods of assessment of urethral function*

3.5.1. *Urethral pressure reflectometry*

Urethral pressure reflectometry (UPR) is a technique that was introduced a decade ago. It measures the pressure and cross-sectional area of the urethra continuously by acoustic reflectometry (using sound waves). The measurement is taken by introducing a thin flexible polyurethane bag placed in the urethra that is connected to a polyvinyl chloride catheter. The theoretical advantage of this method over others is that pressure within the collapsed urethral tube can be measured without distension and changing its natural shape. Measurements are not affected by urethral movement, which avoids artefacts due to catheter or transducer movement. These measurements can be taken with the subject resting or straining, lying down or standing up. UPR was found to give similar pressure reading as UPP but was more reproducible [55,56], and it was used to differentiate between SUI and continent women in a small clinical study [57]. More clinical studies are required before UPR can be recommended in routine clinical practice.

3.5.2. *Circumferential urethral sphincter electromyography*

Electromyography (EMG) is a technique commonly used in neurophysiologic diagnosis but has seldom been used in the routine assessment of urethral sphincter function due to the invasive and painful nature of concentric needle EMG. Circumferential sphincter EMG is a novel and less invasive method of assessing the neuromuscular integrity of the urethral sphincter. Twelve electrodes are arranged in a circumferential configuration on a probe placed into the urethra. In a small study of 44 women, one measured parameter (average rectified value of the motor unit action potential at the 12 o'clock position at maximal contraction) could distinguish between ISD and non-ISD [58]. Further clinical studies are needed to assess whether such findings can be reproduced or help to predict clinical outcomes.

3.5.3. *Biological markers*

Several biomarkers have been investigated for the diagnosis and outcome prediction in overactive bladder. By comparison little work has been conducted in SUI. A recent report by Chai and colleagues described a study in which urinary samples were collected from patients pre- and post-SUI surgery and assayed for inflammatory cytokines and tissue-remodelling biomarkers [59]. The authors found that patients with lower levels of *N*-telopeptide cross-linked collagen were significantly less likely to fail surgery. Further studies are needed to validate this as a possible biomarker in SUI.

4. Conclusions

The primary aim of the evaluation of the patient presenting with SUI is to confirm the diagnosis and assess symptom severity before instituting conservative measures. Urodynamic assessment aims to confirm the diagnosis (where there is doubt), the mechanism(s), and identify factors that may affect treatment outcome. However, whether urodynamic assessment improves long-term outcomes following surgery remains controversial, and there is a lack of high-level evidence to support the assertion that urodynamic assessment can predict complications of surgery.

Classification of SUI into categories of urethral hypermobility and ISD has been attempted using urodynamic and imaging techniques. However, this is likely to oversimplify the situation because of significant overlap between the two mechanisms. Both entities remain poorly defined, and there is a lack of standardisation regarding the performance of tests and equipment used. Several studies have failed to show a correlation between the tests and severity of symptoms. Moving forwards, there is a need for a more sensitive test of urethral function along with well-designed prospective studies to assess clinical and urodynamic risk factors that have an impact on surgical outcome.

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