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TOPIC PAPER

Classification of stress urinary incontinence

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Abstract
Introduction The relevant terminology for stress urinary incontinence (SUI) is affected by the context, namely the clinical assessment (the symptom of SUI elicited on history taking and the sign of SUI observed during examination) or diagnostic investigations (urodynamic stress incontinence). In some cases, SUI may only be observed after the reduction in coexistent prolapse (occult SUI). Classifying SUI often relies on distinguishing between intrinsic sphincter deficiency (ISD), and urethral malposition or hypermobility, although this potentially an over-simplification.
Review Classification systems have been derived based on clinical assessment and diagnostic testing, notably videourodynamics. Modern developments in imaging technology may allow other techniques such as ultrasound to offer additional basis for future developments in classification. Other urodynamic approaches include urethral pressure profilometry and Valsalva leak point pressure; these may offer indicators of thresholds below which ISD is more likely to explain SUI, but they are not generally accepted in routine practice.
Conclusions While SUI classification is potentially relevant to treatment selection, evidence for influence on management outcome is limited. Generating a high-quality evidence base for treatment selection on these criteria is problematic, particularly due to the range of confounding factors. In practice, the modern practitioner relies on various tools to form an opinion on some key aspects, using the findings to derive a treatment strategy. Accordingly, there remains a need to confirm how a classification of SUI translates into treatment selection and better outcomes.

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Introduction

The high prevalence of stress urinary incontinence (SUI) and potential impact on patients is well recognised. This leads to a substantial level of health care resource use, including personal containment products, conservative treatment, surgery and management of complications. Outcomes of treatment can be unsatisfactory, and ongoing research into understanding of mechanisms, SUI diagnosis and treatment is needed. Accordingly, effective and relevant classification of SUI is necessary to underpin progress in the area. The introduction of new treatments relies on demonstration of efficacy, for which patient selection is essential; in this context, SUI classification potentially becomes particularly relevant. This review focusses on the current situation for classifying SUI in women, and some of the issues arising from terminology, clinical assessment and investigation.

Normal continence mechanisms

Continence requires that the resistance of the bladder outlet exceeds intra-vesical pressure. The urinary sphincter (striated muscle) and intrinsic urethral smooth muscle are the crucial outlet muscles determining the state of the bladder outlet in the micturition cycle. They are controlled by lower motor neurones located in Onuf's nucleus in the sacral spinal cord, whose processes pass primarily in the pudendal nerve. During the storage phase of the

micturition cycle, these are the primary structures sustaining tonic closure of the outlet for a person at rest. Physical activity generally raises intra-abdominal pressure, and this is normally associated with reflex enhancement of the contraction of the intrinsic muscles of the bladder outlet, which reinforces outlet contraction at the time necessary to counteract the stress that could otherwise cause SUI. An additional facet considered to be a factor in maintaining continence is the healthy vascularisation of the urethral mucosa and submucosa, enabling "co-aptation" of the urethral wall.

The striated external urethral sphincter is anatomically continuous with the striated muscle of the pelvic floor. Voluntary control of these muscles enables an individual to further enhance outlet resistance in anticipation of physical stress or to interrupt the urinary stream of voiding. The outlet thus has three functional properties based on muscle contraction that serve to prevent SUI:

- Involuntary tonic contraction.
- Reflex phasic contraction in association with physical stress.
- Voluntary phasic contraction.

For the muscle structures to function effectively, they have to be supported by an effective framework, which is provided by the bony pelvis and associated ligaments. The rigidity of the bony structure supports the midline pubourethral ligaments and the lateral attachments of the vagina, as well as providing the anterior attachments of the pelvic floor muscles. Between these anatomical landmarks, the urethra is suspended on the endopelvic fascia (EPF) and anterior vaginal wall, which provide a hammock-like support. Accordingly, the urethra and base of the bladder can be seen to lie at the level of the pubis radiologically (Fig. 1). During stress testing in videourodynamics (VUDS), the extent to which the bladder base descends is minimal.

The proximal part of the urethra is intra-abdominal and is linked to the pubic bone [1]. The portion may have some functional importance, in that changes of intra-abdominal pressure might compress the proximal urethra directly, and so give a slightly increased resistance to counteract the concurrent increase in intra-vesical pressure. The "hammock hypothesis" [2] suggests that the vaginal wall provides a necessary support against which raised intra-abdominal pressure compresses the urethra, again by direct transmission. This anatomical arrangement allows simultaneous distribution of pressure to both the bladder and urethra during any intra-abdominal pressure rises, such as straining, thereby preventing urinary leakage.

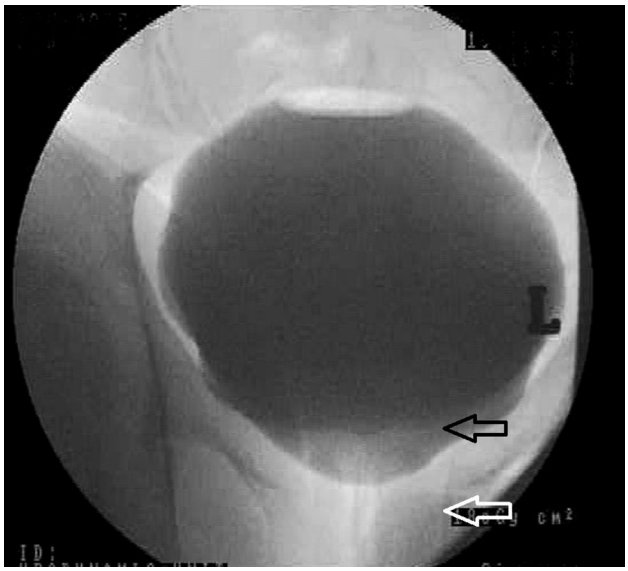

Fig. 1 Still image taken in the antero-posterior viewpoint during a videourodynamic test, showing the bladder filled with contrast, and the base of the bladder lying in its normal location between the level of the superior (*black arrow*) and inferior (*white arrow*) borders of the pubis

Terminology

The relevant terminology is affected by the context, namely the clinical assessment (history and examination) or diagnostic investigations. The symptom of SUI relates to the patient history. The symptom is defined by the International Continence Society (ICS) as the complaint of involuntary leakage on effort or exertion, or on sneezing or coughing [3]. The joint terminology document of the International Urogynecology Association (IUGA) and the ICS describes SUI as the complaint of involuntary loss of urine on effort or physical exertion (e.g. sporting activities), or on sneezing or coughing. To some extent, a slightly different term "effort incontinence" can be regarded as preferable, mainly because "stress" has some connotations of mental state in the English language. However, words such as "effort" or "exertion" still do not capture some of the common precipitating factors for stress incontinence, notably coughing or sneezing [3]. Likewise, "activity-related incontinence" could be considered a suitable alternative [4]. SUI remains the current phrasing for the symptom [3, 4].

The sign of SUI is the observation of involuntary leakage from the urethra, synchronous with exertion/effort, or sneezing or coughing [3]. This might also be described as "clinical stress leakage" [4]. The immediate observation of leakage is crucial, since coughing is a provocation for the bladder which can induce a secondary overactive detrusor contraction, leading to detrusor overactivity incontinence after a short delay.

Hence, the sign of stress incontinence is only a reliable indication of urodynamic stress incontinence when leakage occurs synchronously with the first proper cough and stops at the end of that cough [3]. Stress incontinence on prolapse reduction (occult or latent stress incontinence) refers to the sign of stress incontinence only observed after the reduction in coexistent prolapse [4]. The reduction in the prolapse has to be done appropriately when examining to establish whether occult SUI is present, since a pessary or ring might obstruct the urethra, giving a false negative for this sign [4].

In the context of filling cystometry, urodynamic stress incontinence (USI) is the involuntary leakage of urine, associated with increased intra-abdominal pressure, in the absence of a detrusor contraction [3, 4]. USI is the term that replaces the older term "genuine stress incontinence", which is no longer in use. A diagnosis of USI may be made in the absence of the symptom of SUI in women who have the sign of occult or latent stress incontinence [4].

Pathophysiology of stress urinary incontinence

The proper function of the tonic contraction of the intrinsic muscles is a fundamental property, which is at risk in the event of direct trauma to the muscle and may be at risk in the presence of relevant myopathy. Since muscle contraction is dependent on the lower motor neurones in Onuf's nucleus, neurological disease or trauma affecting the sacral spinal cord or pudendal nerve will also risk tonic urethral closure. Relevant neurological disease may also affect the reflex enhancement of intrinsic closure seen with physical activity. In these situations, the anatomical location of the urethra can be normal, and it is the "intrinsic sphincter deficiency" (ISD) due to lack of muscle function that places a woman at risk of SUI. Age can be an independent risk factor for the development of ISD [5]. Accordingly, it may be inferred that age-related reduction in muscle mass and nerve or muscle dysfunction may contribute to stress incontinence.

The supportive "platform" needed for intrinsic urethral function is at risk from various impairments. These are likely to affect the normal anatomical lie of the urethra, either at rest (urethral malposition), or during a rise in intra-abdominal pressure (urethral hypermobility). Conceivably, several processes can impair the supportive structures:

- Damage to the pubo-urethral ligament, causing posterior displacement of the urethra.
- Impairment of the lateral supports, affecting the hammock back-plate provided by the vagina.
- Deficiency in the endopelvic fascia, associated with descent of the proximal portion of the urethra, reducing the direct transmission of the intra-abdominal pressure enhancing urethral closure.
- Damage to the levator ani, allowing descent of the bladder base and outlet, placing several aspects of the continence mechanisms at risk.

In reality, there are many factors at work, and recent work has attempted to consolidate the anatomical and functional aetiologies into a unified approach (reviewed in [6]). Clearly, some pathological processes place a woman at risk of both sphincter deficiency and urethral hypermobility/malposition. For example, a myopathic process that affects both the levator ani and the sphincter muscle could cause urethral hypermobility and sphincter deficiency. Likewise, a bony fracture of the pubis could damage both the sphincter and the pubo-urethral ligaments. Since support for all the pelvic floor structures is interlinked, it is common for the above derangements to be associated with pelvic organ prolapse (POP). Potentially, this can have further influence by distorting the urethra, which could lead to partial bladder outlet obstruction (BOO) and masking of SUI ("occult SUI").

Clinical systems for classifying SUI in female patients

A clear distinction could be made between ISD and urethral malposition/hypermobility, and cataloguing women with SUI into "hypermobile" or "ISD" pathophysiology is commonly done. In reality, however, the nature of the urethral structure and function is probably a spectrum which can take up any intermediary form between the extremes of a highly mobile urethra with good intrinsic function to an immobile urethra with poor intrinsic function [3]. There is also the possibility of a highly mobile urethra with poor intrinsic sphincter function. Thus, any delineation into such discrete categories may be simplistic and arbitrary and requires further research [3].

Blaivas proposed the following scheme, based on clinical assessment [7]:

Type 0	Typical history of stress incontinence, but incontinence is not reproduced during the examination. The vesical neck and urethra descend during cough or strain (clinical examination or cystogram) and the urethra opens, but there is no leakage. Maximum urethral closure pressure is normal. In this type of incontinence, the patient is probably able to prevent leakage by momentarily contracting the external urethral sphincter.
Type I	Minimal descent of the vesical neck and urethra during stress with visible urinary leakage. No cystocoele. Normal maximum urethral closure pressure.

Table 1 Classification of SUI based on videourodynamic parameters [9]

Type	At rest	Stressed (cough)
0	Flat bladder base above symphysis pubis	Rotational descent of urethra and bladder base; no leakage
I	Flat bladder base above symphysis pubis	Bladder base descends; vesical neck and urethra open with leakage
IIA	Flat bladder base above symphysis pubis	Cough: marked descent and rotation of bladder and urethra below pubis; urethra opens widely with leakage
IIB	Flat bladder base below symphysis pubis	Further descent and rotation of bladder and urethra below pubis; urethra opens widely with leakage
III	Bladder base above symphysis pubis; vesical neck and urethra open	Bladder base above symphysis pubis; vesical neck and urethra open

Type II Obvious cystourethrocoele present with visible urinary leakage during stress. Normal maximum urethral closure pressure.

Type III Vesical neck open during bladder filling without concomitant detrusor contraction. Visible urinary leakage with no or minimal stress. Variable vesical neck and urethral descent (often none at all). Maximal urethral closure pressure very low.

Videourodynamics is a plausible method for categorising the mechanism of SUI in individual women, and relevant features have long been recognised [8], including:

- Hypermobility of the proximal urethra with loss of its intra-abdominal position during stress, associated with changes in the urethrovesical angle.
- Fixation of the posterior urethra.
- Loss of effective urethral length.

A classification system was derived which derives from the position of the bladder base at rest and with physical stress, along with the resting state of the outlet (Table 1) [9]. This remains a well-recognised approach, and developments in other imaging modalities can be used to infer some of the relevant features. Current routine possible uses of ultrasound [4] are able to study several aspects which might offer another modality for deriving relevant information;

1. Bladder neck descent/mobility/opening.
2. Position of the bladder neck during pelvic floor contraction.
3. Retrovesical angle (RVA): angle between proximal urethra and trigonal surface of the bladder.
4. Urethral rotation: rotation of the proximal urethra on Valsalva.
5. Angle gamma: angle defined by lines from the inferoposterior symphyseal margin to the bladder neck at rest and on Valsalva.
6. Urethral funnelling: opening of the proximal third of the urethra during coughing or on Valsalva.
7. Urine loss: Full urethral opening during coughing, Valsalva, bladder contraction or micturition.

Some of these aspects can be assessed using intra-vaginal and transperineal [10] ultrasound. Consensus has not been reached on criteria for excessive bladder neck mobility nor the relationship of this finding to a diagnosis of USI. Nonetheless, professional consensus may be able to agree parameters for modifying the classification of SUI using new imaging opportunities.

Two further urodynamic techniques are relevant in categorising SUI. The urethral pressure profile (UPP) can be used to measure maximum urethral pressure, maximum urethral closure pressure (MUCP) and functional profile length, at rest and during physical stress. A specific threshold value of the MUCP to categorise women according to subsequent treatment selection has long been considered relevant (e.g. [11, 12]), with 20-cm H_2O being best established [13]. However, the role of MUCP in predicting outcome after midurethral tape is nowadays considered debatable, due to conflicting evidence [14–16]. In reality, the assessment of UPP is rarely used in standard practice currently, and it does not appear to satisfy the criteria of a diagnostic test, even though urethral closure pressures are lower than normal in women with SUI [17].

The Valsalva leak point pressure (VLPP) is the intravesical pressure at which urine leakage occurs due to an increase in intra-abdominal pressure in the absence of detrusor contraction [18, 19]. During filling cystometry, quantitative evaluation has been correlated with clinical evaluation, with ISD being ascribed to the majority of women with a VLPP below 60-cm H_2O, while SUI due to urethral hypermobility is more commonly associated with VLPP >90 cm. Variations in VLPP measurement still need precise description, standardisation and validation [18], so this parameter remains inconsistently used in the clinical setting.

Categorising mechanism of SUI in individual women

The importance of classification of SUI is to define characteristics that may be relevant to treatment selection. The role of midurethral tape (MUT) placement or colpo-suspension in reproviding mechanisms of support and direct transmission of intra-abdominal pressure variation suggests that women with minimal urethral malposition/hypermobility are unlikely to benefit from these interventions. The facility to place an autologous sling under tension, which is contraindicated in MUTs, suggests they are the more appropriate surgical choice where ISD is a substantial component. However, generating a high-quality evidence base for basing treatment selection on these criteria is problematic, for a range of practical reasons, particularly the large number of confounding factors. Since correspondence of SUI classification with associated treatment outcome is largely untested with robust clinical trial protocols, clinicians have largely moved away from attempting to categorise women by objective means.

History and physical examination are the starting point in determining the presence of SUI and indicators of underlying mechanism(s). They provide a clinical indicator of the presence of SUI as a symptom and/or a sign. They need to elicit any indicators of a medical or obstetric risk factor for neuropathy, myopathy or pelvic trauma. Such factors may already be known, but the clinician needs to consider whether an undiagnosed condition may be present. Physical examination should systematically explore:

- Urethral descent, assessed at rest and on straining. Placement of a cotton bud (Q-tip) into the urethra has been used as an indicator of the characteristic forward rotation with descent of the urethra and the strength/endurance of pubo-coccygeus muscle [20], though most investigators feel this is not needed.
- POP, quantified by clinical assessment, such as the International Continence Society POP quantification (POP-Q) or the Baden and Walker method [21].
- Strength and endurance of the pelvic floor muscle, graded, for example, by the Oxford grading system.
- Indicative features such as loss of lateral support of the vagina or epithelial atrophy.

Accordingly, examination can be used to categorise women as having SUI and urethral hypermobility. Sufficient provocation must be performed to precipitate the SUI which the patient describes. This should include an adequate cough series, combined if necessary with position change (e.g. squatting) and more active exertion (e.g. star jumps and jogging). It may be difficult to demonstrate detrusor overactivity in patients with severe SUI, or vice versa. However, attempts should be made to demonstrate other diagnoses, as these may affect management. In addition, a significant prolapse may affect test results and therefore should be reduced with repeat examination where possible.

A rational approach based on long-standing experience was set out by Blaivas [22], using a range of assessments; (1) the patient's history (to document the symptom), (2) the physical examination (to document the sign), (3) a micturition diary (to corroborate the symptom), (4) a pad test (to document the volume of urinary loss), (5) the leak point pressure (to quantitate sphincter strength) and (6) a measure of urethral hypermobility. In modern practice, a compilation of observations is still used to hone the clinical picture for individual women; while subjective measures of severity are now more commonplace, and physical examination is relied on in the uncomplicated case, the overall approach remains relevant nowadays. In practice, the modern practitioner relies on various tools to form an opinion on some key aspects, using the findings to gauge a treatment strategy that is often rather different between centres.

Conclusions

The purpose of classification of SUI is to facilitate our understanding of aetiology and pathophysiology, so that treatment guidelines can be established. The clinical aspiration is to identify the most effective type of surgical treatment and to provide insight into potential failures. There are many challenges, including mixed pathophysiological mechanisms, standardisation of testing, and ascertaining the relative contributions of hypermobility and sphincter deficiency. Despite the importance of the topic for female urology and urogynaecology, there is even now a crucial need to confirm how a classification of SUI translates into treatment selection and better outcomes.

Compliance with ethical standards

Conflict of interest All contributors made a substantive contribution in the preparation of this manuscript. There were no applicable conflicts of interest.

Ethical standard Ethical committee review was not required as the manuscript is a review of the published literature.

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