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ORIGINAL ARTICLE

# “The cough game”: are there characteristic urethrovesical movement patterns associated with stress incontinence?

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**Abstract** This study was carried out to determine whether five experts in female stress urinary incontinence (SUI) could discover a pattern of urethrovesical movement characteristic of SUI on dynamic perineal ultrasound. A secondary analysis of data from a case–control study was performed. Ultrasounds from 31 cases (daily SUI) and 42 controls (continent volunteers) of similar age and parity were analyzed. Perineal ultrasound was performed during a single cough. The five experts, blinded to continence status and urodynamics, classified each woman as stress continent or incontinent. Correct responses ranged from 45.7% to 65.8% (mean 57.4±7.6). Sensitivity was 53.0±8.8% and specificity 61.2±12.4%. The positive predictive value was 48.8±8.2% and negative predictive value was 65.0±7.3%. Inter-rater reliability, evaluated by Cohen’s kappa statistic, averaged 0.47 [95% CI 0.40–0.50]. Experts could not identify a pattern of urethrovesical movement characteristic of SUI on ultrasound.

**Keywords** Stress urinary incontinence · Ultrasound · Urethrovesical movement

**Abbreviations**

SUI stress urinary incontinence
MUCP maximum urethral closure pressure

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## Introduction

Because urethrovesical mobility and stress urinary incontinence (SUI) commonly coexist in clinical practice, several different approaches have been developed to assess the value of quantifying urethrovesical mobility on ultrasound in the diagnostic evaluation of SUI. Most of these focus on linear movement of the bladder neck or angle changes of the urethrovesical junction on transperineal ultrasound in continent and stress incontinent women and have produced differing results. For example, stress incontinent women with clinical urethral hypermobility demonstrate greater bladder neck descent on ultrasound than those women without hypermobility [1], indicating a correlation between clinical exam and ultrasound findings. Yet, using vector-based formulas, bladder neck movement on ultrasound at rest and with coughing/Valsalva has been documented in both continent and incontinent patients [2].

Our research group has also utilized various schemes to quantify urethrovesical position [3]. These approaches also focus on the simple movement of a single point or axis and only capture a small portion of the rich and complex movement of viscera (like the urethra and bladder base) and shape changes (such as funneling) that can occur with increases in intra-abdominal pressure. In addition, the timing and rapidity of movement is not captured with these uni-dimensional schemes. We wondered whether experts with significant experience in the evaluation of urethrovesical hypermobility on ultrasound, could identify specific patterns of movement characteristic of stress incontinence when not constrained by quantitative schemes; we hoped to then analyze these identified patterns. We did not intend to evaluate ultrasound as a diagnostic tool for SUI; rather, we hoped to discern patterns of mobility as a basis for the future development of an objective evaluation technique.

## Materials and methods

This study represents a secondary analysis of a case–control study concerning mechanisms of stress urinary incontinence [4]. Ultrasound images were selected from this study for blinded review by an expert panel. All ultrasound images that had optimal visibility of landmarks (to ensure that evaluators were not limited by image quality) were included in the study. Cases included 31 women who reported daily SUI, confirmed in the clinic with a positive full bladder stress test, and controls included 42 continent volunteers. Both groups were recruited from the outpatient clinics at the University of Michigan and by advertisement in local news media.

Each subject underwent a standardized pelvic organ prolapse quantification exam (POP-Q) with Q-tip angle measurements during cough and Valsalva. Multichannel urodynamic testing was performed with an 8 Fr micro-tip dual sensor Gaeltec™ catheter (Medical Measurements Inc., Hackensack, NJ, USA) and a 10 Fr filling catheter. The bladder was retrograde filled at 50 mL/min with normal saline for a total volume of 300 mL. After testing was completed, prior to emptying the bladder, a perineal ultrasound was performed in the standing position. The transducer was lightly positioned on the vulva in a mid-sagittal orientation to clearly visualize the pubic bone, urethra, bladder, and vesical neck without displacing or compressing the urethra. Patients then performed several single, maximal coughs while dynamic images were recorded with simultaneous image capture and pressure recording. The best cough was selected based on clarity of the picture (visible pubic bone, urethra, and ureterovesical junction) and highest abdominal pressure achieved. Because Doppler was not utilized, leakage of urine was not visible. All images were de-identified and video clips were placed in a PowerPoint presentation in random fashion for review.

The five expert urologists and urogynecologists, each of whom has published on the topic of urethral mobility and urinary incontinence, were given a CD with the presentation and a scoring sheet. Observing only the scan, evaluators were asked to give their opinion on whether or not each subject had SUI. No specific instructions were given to direct the evaluators in their observation of the motion on the ultrasound. Evaluators also indicated on the scoring sheet how sure they were about their opinions by marking “confident”, “likely”, or “unsure”.

Statistical analysis was performed with SPSS 14.0 for Windows (SPSS, Inc. Chicago, IL, USA). Kappa coefficients were calculated for inter-rater reliability, Chi-square tests were used for categorical data and McNemar’s test for nominal data. A $p$ value <0.05 was regarded as statistically significant. The study was approved by the University of Michigan’s Institutional Review Board (IRB# 2002-0636).

## Results

Subjects were matched for age, parity, and race. The mean age of subjects was 46.4±10.1 years, mean BMI was 28.1±6.3 kg/m$^2$, 97% were Caucasian, and median vaginal parity was 2. Based solely on ultrasound observation, the five evaluators scored with accuracies ranging from 45.7% to 65.8% (mean 57.4±7.61). When their opinions of continence status were self-reported as being “confident” or “likely”, these percentages changed only minimally (mean 58.2±8.9) (Table 1) and lacked statistical significance ($p$=0.3). The sensitivity of ultrasound in detecting stress urinary incontinence was calculated to be 53.0±8.8% and specificity 61.2±12.4%. The overall positive predictive value was calculated to be 48.8±8.2% and negative predictive value 65.0±7.3%.

**Table 1** Overall accuracy

| Evaluator | % Correct (absolute) | % Correct if “confident or likely” |
|---|---|---|
| A | 60.9 | 68.9 |
| B | 65.8 | 67.5 |
| C | 59.7 | 62.6 |
| D | 54.8 | 54.0 |
| E | 45.7 | 44.5 |

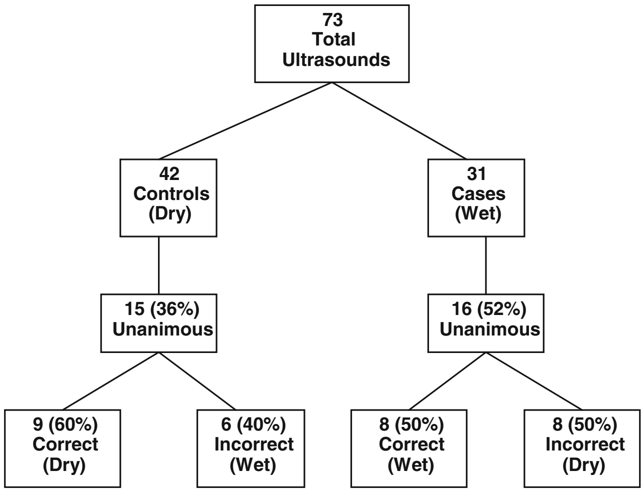


**Fig. 1** Distribution of unanimous concordance among evaluators in cases vs. controls

Overall classification concordance among the evaluators was then examined. All five evaluators unanimously agreed in their continence diagnosis on 31 out of the total 73 (42%) scans. However, these unanimous classifications were correct on only 17 of 31 (55%) ultrasounds scans and incorrect on 14 of 31 (45%) scans. Similarly, the distribution of unanimous concordance and accuracy among the evaluators did not differ significantly when ultrasounds in patients with SUI (cases) and those without (controls) were analyzed separately. However, evaluators were more likely to be correct in their agreement for patients without stress urinary incontinence (Fig. 1). Inter-rater reliability, evaluated by Cohen's kappa statistic, averaged 0.47 [95% CI 0.40–0.53].

Data from pelvic floor testing was compared between patients unanimously presumed to have stress incontinence and those unanimously presumed to be continent, irrespective of whether these were correct diagnoses. Patients presumed to have SUI by all evaluators had significantly greater urethral axis/mobility (degrees) at rest (3.21 vs. −11.8, $p$=0.004) and with strain (41.8 vs. 20.6, $p$=0.002) than those presumed to be continent. No other differences in pelvic floor data were observed (Table 2).

## Discussion

Experts were only 7% above random chance in predicting whether or not a woman had stress incontinence (as shown by their overall mean accuracy of 57.4%) by observing dynamic movement during a cough on perineal ultrasound and were unable to identify a pattern of movement associated with SUI. These findings, conducted in groups of women matched for age and parity, may further suggest that urethrovesical movement may not be as strongly associated with the occurrence of SUI as has been described and also emphasize the role of urethral function in maintaining continence [4]. Even when reviewers unanimously agreed that a movement pattern would be associated with SUI, their predictive ability did not improve. This is emphasized by the detected overall sensitivity of 53%. While concordance among reviewers exists, accuracy is only average (Table 1, Fig. 1).

In addition to evaluating urethral mobility as a factor in the pathophysiology of SUI, ultrasound and Q-tip angle have also been suggested as diagnostic tools for SUI. The imaging of hypermobility for this purpose is debated by authors. In many studies, it has low predictive value [5, 6]. Chen et al. found that even if bladder neck rotational angle exceeds 28°, the sensitivity of ultrasound in predicting SUI was only 73% [7]. Sendag et al. showed some difference in urethrovesical angle changes between women with and without SUI; the patients were not, however, matched for age or parity [8]. Benson et al. also described urethrovesical junction hypermobility in patients with stress urinary incontinence on perineal ultrasound [9] and more recently, others have found that retrovesical angle rotation and bladder neck descent at Valsalva on ultrasound are strongly associated with genuine stress incontinence [10, 11]. When analysis focuses on ultrasound visualization of bladder leakage rather than simple assessment of mobility patterns, sensitivity in diagnosing SUI is much higher [12]. This technique, however, uses ultrasound to establish if leakage occurs, an issue independent of whether urethral mobility is associated with ultrasound diagnosis of SUI. On the other hand, when urine leakage cannot be seen and only bladder

**Table 2** Data from pelvic floor testing of patients unanimously presumed to have SUI vs. those presumed to be continent (non-SUI)

| | Presumed non-SUI by all $N$=17[a] | Presumed SUI by all $N$=14[a] | [95% CI] | $p$ |
|---|---|---|---|---|
| Cough pressure (cm $H_2O$) | 135.1 | 136.7 | −40.4 37.1 | 0.93 |
| Q-tip angle rest (°) | −11.8 | 3.21 | −25.1 −5.0 | 0.004 |
| Q-tip angle strain (°) | 20.6 | 41.8 | −33.5 −9.0 | 0.002 |
| Q-tip angle change (°) | 32.4 | 38.6 | −14.2 1.8 | 0.13 |
| MUCP (cm $H_2O$) | 54.4 | 56.0 | −16.5 13.2 | 0.82 |

[a] Values reported as means

neck descent is considered, Martin et al. described a decrease in sensitivity to 84% in a systematic review [13].

Many of these previous studies that cite stronger associations between sonographically documented urethral mobility and clinically documented SUI have methodological limitations. For example, several studies have used women with symptoms of lower urinary tract dysfunction in the absence of stress incontinence during evaluation as controls [14]. Another study utilized a control group with significant differences from the study group in both age and parity [15]. Having controls that are younger than cases with SUI could bias the results and may be partly responsible for earlier studies revealing greater differences between groups. Younger control women can be expected to have higher urethral closure pressure [16] while nulliparas have better urethral support than parous continent women [17]. Our findings are strengthened in that they occurred in a study of cases and controls matched for age and parity, thus eliminating these confounding variables.

As a clinical measure of hypermobility, the reliability of the Q-tip test varies because of its inherent limitations including improper placement of the Q-tip into the urethra and the somewhat arbitrary cutoff of 30° to define hypermobility. However, in clinical practice, it is generally a reliable method of quantifying mobility of the bladder neck and proximal urethra [18]. Bai et al. showed a sensitivity of 93% and positive predictive value of 68%; however, specificity was only 18% and negative predictive value 60% [19]. In this study, Q-tip angle was the only parameter that showed a positive correlation with a presumed diagnosis of SUI on ultrasound. Subjects presumed to have SUI by all evaluators (either correctly or incorrectly) had significantly greater urethral axis/mobility at rest and with strain, emphasizing that mobility may have been most influential in evaluators' assessments. Yet, the greater mobility seen in these patients on ultrasound did not correspond to an accurate assessment of continence status. In fact, accuracy was only 50% when all evaluators presumed a patient had SUI (Fig. 1).

In evaluating the factors contributing to SUI, urethral and vesical neck function also play a significant role. Oliveira et al. correlated increasing urethral luminal diameter on ultrasound with stress incontinence and intrinsic sphincter deficiency (ISD) when compared with continent women. Ninety-two percent of women with ISD had urethral luminal diameters >6 mm [20]. However, while urethral funneling is seen in certain patients with SUI, its diagnostic relevance is uncertain [21]. In this study, mean maximum urethral closure pressure (MUCP) did not differ among patients presumed to have SUI and those presumed to be continent by all evaluators (Table 2). This would suggest that vesical neck and urethral diameters as seen on ultrasound did not influence evaluators in their continence diagnosis.

There are several limiting factors that should be considered in interpreting the results of this study. Because we were seeking to identify specific patterns of movement, we focused on an individual's best and hardest cough rather than a series of coughs. We selected scans of good image quality, eliminating scans where visibility was less than optimal. This alone could introduce bias if one group of women tended to have better images than the other. The individuals selected did not, however, differ demographically from the overall study group. Women with SUI may have been presumed to be continent because they did not cough hard enough to leak during their ultrasound. While it is not possible to determine retrospectively if leakage occurred during the scan, the cough pressures recorded during the majority of coughs reached leak point pressures determined during urodynamics. In future studies, it would be important to document actual leakage in women with SUI at the time of the perineal ultrasound. Finally, the evaluators were not specifically asked to reveal the particular movements or pattern of movements that influenced them in their continence diagnosis; it was the intent of the study to allow them to use whatever observations they deemed important in determining stress incontinence. Thus, while hypermobility correlated with a diagnosis of SUI, this is only an indirect measure of the evaluators' influences.

In conclusion, even with the elimination of restrictive measurement schemes that focus on a single point, angle, or axis, we have shown that, to expert eyes, the patterns of motion of pelvic viscera on ultrasound did not correlate with continence status. By selecting truly asymptomatic controls of similar age and parity to the study group, we have minimized differences that may confound the analysis. While the paradigm of urethral support loss leading to stress urinary incontinence is an important one, results of this study suggest that other factors such as urethral function may play a more important role than previously thought.

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**Conflicts of interest** None.

## References

1. Bai SW, Kwon JY, Chung DJ, Park JH, Kim SK (2006) Differences in urodynamic study, perineal sonography and

treatment outcome according to urethrovesical junction hypermobility in stress urinary incontinence. J Obstet Gynaecol Res 32: 206–211
2. Schaer GN, Perucchini D, Munz E, Peschers U, Koechli OR, Delancey JO (1999) Sonographic evaluation of the bladder neck in continent and stress-incontinent women. Obstet Gynecol 93:412–416
3. Reddy AP, DeLancey JO, Zwica LM, Ashton-Miller JA (2001) On-screen vector-based ultrasound assessment of vesical neck movement. Am J Obstet Gynecol 185:65–70
4. DeLancey JOL, Trowbridge ER, Miller JM, Morgan DM, Guire K, Fenner DE (2008) Stress urinary incontinence: relative importance of urethral closure pressure. J Urology 179:2286–2290
5. Hol M, van Bolhuis C, Vierhout ME (1995) Vaginal ultrasound studies of bladder neck mobility. Br J Obstet Gynaecol 102:47–53
6. Dalpiaz O, Curti P (2006) Role of perineal ultrasound in the evaluation of urinary stress incontinence and pelvic organ prolapse: a systematic review. Neurourol Urodyn 25:301–307
7. Chen GD, Su TH, Lin LY (1997) Applicability of perineal sonography in anatomical evaluation of bladder neck in women with and without genuine stress incontinence. J Clin Ultrasound 25:189–194
8. Sendag F, Vidinli H, Kazandi M, Itil IM, Askar N, Vidinli B et al (2003) Role of perineal sonography in the evaluation of patients with stress urinary incontinence. Aust N Z J Obstet Gynaecol 43: 54–57
9. Benson JT, Sumners JE, Pittman JS (1991) Definition of normal female pelvic floor anatomy using ultrasonographic techniques. J Clin Ultrasound 19:275–282
10. Dietz HP, Clarke B, Herbison P (2002) Bladder neck mobility and urethral closure pressure as predictors of genuine stress incontinence. Int Urogynecol J Pelvic Floor Dysfunct 13:289–293
11. Minardi D, Piloni V, Amadi A, El Asmar Z, Milanese G, Muzzonigro G (2007) Correlation between urodynamics and perineal ultrasound in female patients with urinary incontinence. Neurourol Urodyn 26:176–184
12. Dietz HP, Clarke B (2001) Translabial color Doppler urodynamics. Int Urogynecol J Pelvic Floor Dysfunct 12:304–307
13. Martin JL, Williams KS, Sutton AJ, Abrams KR, Assassa RP (2006) Systematic review and meta-analysis of methods of diagnostic assessment for urinary incontinence. Neurourol Urodyn 25:674–684
14. Bai SW, Kang JY, Rha KH, Lee MS, Kim JY, Park KH (2002) Relationship of urodynamic parameters and obesity in women with stress urinary incontinence. J Reprod Med 47:559–563
15. Cassado J, Pessarrodona A, Tulleuda R, Cabero L, Valls M, Quintana S et al (2006) Introital ultrasonography: a comparison of women with stress incontinence due to urethral hypermobility and continent women. BJU Int 98:822–828
16. Borstad E, Rud T (1989) The risk of developing urinary stress-incontinence after vaginal repair in continent women. A clinical and urodynamic follow-up study. Acta Obstet Gynecol Scand 68: 545–549
17. DeLancey JOL, Miller JM, Kearney R, Howard D, Reddy P, Umek W et al (2007) Vaginal birth and de novo stress incontinence; relative contributions of urethral dysfunction and mobility. Obstet Gynecol 110:354–362
18. Karram MM, Bhatia NN (1988) The Q-tip test: standardization of the technique and its interpretation in women with urinary incontinence. Obstet Gynecol 71:807–811
19. Bai SW, Woo JW, Shin JS, Park JH, Kim SK, Park KH (2004) The predictive values of various parameters in the diagnosis of stress urinary incontinence. Yonsei Med J 45:287–292
20. Oliveira FR, Ramos JG, Martins-Costa S (2006) Translabial ultrasonography in the assessment of urethral diameter and intrinsic urethral sphincter deficiency. J Ultrasound Med 25: 1153–1158
21. Tunn R, Goldammer K, Gauruder-Burmester A, Wildt B, Beyersdorff D (2005) Pathogenesis of urethral funneling in women with stress urinary incontinence assessed by introital ultrasound. Ultrasound Obstet Gynecol 26:287–292