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Urodynamics, the supine empty bladder stress test, and incontinence severity

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Abstract

Aims—Determine whether urodynamic measures of urethral function [(Valsalva leak point pressure (VLPP); maximal urethral closure pressure (MUCP); functional urethral length (FUL)] and the results of the supine empty bladder stress test (SEBST) correlate with each other and with subjective and objective measures of urinary incontinence (UI).

Methods—Data were collected preoperatively from subjects enrolled in a multicenter surgical trial of midurethral slings. Subjective measures included questionnaire scores from the Medical Epidemiological and Social Aspects of Aging questionnaire, Urogenital Distress Inventory, and Incontinence Impact Questionnaire. Objective measures included a 24-hour pad weight test, incontinence episode frequency on a 3-day voiding diary, and a SEBST.

Results—597 women enrolled. 372 women had valid VLPP values; 539 had valid MUCP/FUL values. Subjective measures of severity had weak to moderate correlation with each other and with objective measures of severity. VLPP and MUCP had moderate correlation with each other ($r = 0.36$, $p < 0.001$). Urodynamic measures of urethral function had little or no correlation with subjective or objective measures of severity. Subjects with a positive SEBST had more severe subjective and objective severity measures compared to the negative SEBST group, but they did not have significantly different VLPP and MUCP values.

Conclusions—VLPP and MUCP have moderate correlation with each other, but each had little or no correlation with subjective or objective measures of severity or with the results of the SEBST. This data suggests that the urodynamic measures of urethral function are not related to subjective or objective measures of UI severity.

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Keywords

Correlation; empty bladder stress test; Maximum Urethral Closure Pressure (MUCP); severity; stress urinary incontinence; Valsalva Leak Point Pressure (VLPP)

Introduction

Stress urinary incontinence (SUI) results when urethral resistance is overcome by increases in intra-abdominal pressure. Severely compromised urethral integrity should be associated with more severe incontinence.

A wide range of methods have been proposed to measure the severity of urinary incontinence (UI) including subjective measures like condition-specific symptom and quality of life questionnaires, and objective measures like voiding diary incontinence episodes, pad weight (PW) testing, or the results of a supine empty bladder stress test (SEBST). Urodynamic testing aims to objectively quantify urethral function and guide treatment by identifying patients with worse urethral function clinically recognized as intrinsic sphincter deficiency (ISD). The most common urodynamic tests of urethral function are the urethral pressure profile (UPP) and the Valsalva leak point pressure (VLPP). The two most common UPP measures evaluated in clinical practice are the maximum urethral closure pressure (MUCP) and the functional urethral length (FUL). The VLPP measures the amount of pressure required to overcome urethral resistance (ie. produce urine leakage) during a Valsalva maneuver.

Intuitively, subjective and objective measures of stress urinary incontinence severity should correlate with urodynamic measures of urethral function, but this has not been clearly demonstrated. For instance, some studies have shown that women with more severe symptoms of incontinence are more likely to have a low VLPP.^{1, 2} In addition, others have found that both MUCP and VLPP correlate with the severity of SUI.³ However, in the Stress Incontinence Surgical Treatment Efficacy Trial (SISTER) study, in which 655 women from many sites across the United States women underwent surgical correction of stress incontinence, VLPP was weakly correlated or not at all correlated with the other severity measures.⁴

Some practitioners use a negative supine empty bladder stress test (SEBST), obtained immediately after voiding, as a negative screening test for ISD. This practice is supported by a study in 179 women which showed that a negative test had a negative predictive value of 90% for a low LPP.⁵ However, we previously reported in the SISTER study that delta VLPP (measured as the increase over baseline) was significantly lower in patients with a positive SEBST vs. a negative SEBST (75 H₂O, vs. 85 cm H₂O, $p = 0.01$), but this difference did not seem clinically meaningful.⁴

The purpose of this study is to determine whether urodynamic measures of urethral function and the results of the SEBST correlate with each other and with subjective and objective measures of urinary incontinence.

Methods

The Trial Of Mid Urethral Slings (TOMUS) study was conducted across nine clinical sites within the United States as part of the Urinary Incontinence Treatment Network (UITN).⁶ It was approved by the Institutional Review Boards at all 9 clinical sites and the biostatistical coordinating center. Briefly, 597 women with either pure or predominant SUI based on their responses to the Medical Epidemiologic and Social Aspects of Aging (MESA)

questionnaire ⁷ were randomly assigned to undergo either a retropubic or transobturator mid urethral synthetic sling. All women demonstrated SUI on pre-operative bladder stress test and had pelvic organ prolapse assessment with Pelvic Organ Prolapse Quantification (POPQ) exam. Exclusion criteria included capacity of less than 200 ml, PVR > 100 ml (unless prolapse was present), previous history of urethral sling surgery, or need for concomitant surgery requiring graft. Preoperative subjective measures of severity included the following questionnaires: Medical Epidemiological and Social Aspects of Aging (MESA) ⁷: total scores and stress component, Incontinence Impact Questionnaire (IIQ) ⁸ and Urogenital Distress Inventory (UDI) ⁸: total scores and stress component. Preoperative objective measures of UI severity included a 24 hour weighted pad test (PW) and incontinence episode frequency (IEF) from a 3 day voiding diary.

The SEBST was performed during an office evaluation in a standardized fashion. After voiding, the patient was placed in the supine position and asked to perform cough and Valsalva straining maneuvers. A positive test was recorded if urethral leakage was observed from the meatus coincident during any maneuver. A catheter was then placed for residual determination; 75% of the residuals were less than 40 ml. If the subject had a negative SEBST, the bladder was filled retrograde to 300 ml for a stress test supine and then standing if necessary at this higher bladder volume. All subjects in this study had demonstrable stress incontinence (a positive stress test).

Urodynamics

All subjects underwent preoperative urodynamic studies (UDS) with the surgeon blinded to the results. UDS included noninvasive uroflow studies, urethral pressure profilometry, filling cystometry, and pressure flow studies. The UDS was standardized at all sites according to our protocol and processes describing our filling cystometry and pressure flow studies have been published. ^{9, 10} Nomenclature conformed to ICS recommendations ¹¹ and technique conformed to ICS recommended good urodynamic practice guidelines. ¹² The quality control evaluation of our signals and interpretations has been published and acceptable inter-rater reliability measures have been demonstrated. ^{9, 10, 13}

UPPs were performed after nonintubated uroflowmetry and prior to the filling cystometry in accordance with a standardized UPP protocol that conformed to the ICS definition of urethral pressure “as the fluid pressure needed to just open a closed (collapsed) urethra”. ¹⁴ All studies were performed with fluid based external transducers using similar equipment (Laborie Medical, Toronto Canada). The UPP studies were performed with subjects in the supine position using a 7 French triple lumen catheter with the urethral measuring system perfused using a flow restrictor at 0.5 ml/min. The catheter was advanced into the bladder so that both vesical pressure (p_{ves}) and urethral pressure (p_{ura}) apertures were intravesical. Both channels were verified to be functioning with a Valsalva and cough maneuver confirming appropriate similar deflections and then the catheter was withdrawn at 1 mm/sec with an electronic puller. Urethral closure pressure (p_{clo}) was calculated from the 2 channels by subtracting p_{ves} from p_{ura} . Three UPP withdrawals were performed measuring FUL and MUCP; the subject had to have at least 2 valid profilometries ($FUL < 50$ mm) for MUCP/FUL data inclusion. Filling cystometry was performed with an infusion rate of 50 ml/min with the subject in the standing position using the same catheter and urodynamic system, but without continued perfused urethral measurements. A fluid filled rectal balloon catheter measured abdominal pressure (p_{abd}). Detrusor pressure (p_{det}) was measured with continuous subtraction ($p_{det} = p_{ves} - p_{abd}$). The external transducers were placed at the level of the symphysis, the system was zeroed to atmosphere and all measures were reported relative to atmospheric pressure including the VLPP. VLPP determinations were first attempted at an infused volume of 200 ml. Each VLPP assessment consisted of 3 gradual Valsalva efforts during which at least 2 had to be associated with leakage for the VLPP to be valid. If no

leakage was seen, repeat VLPPs were repeated at 100 cc intervals until leakage was documented or until the patient reached cystometric capacity.

Statistical Analysis

Descriptive statistics (mean, standard deviation and range) were calculated for baseline UI severity measures. For non-normally distributed variables, data were presented using median and interquartile range. The linear relationships between urodynamic severity measures were explored graphically using linear regression analysis. To investigate the relationships between the incontinence severity measures, non-parametric (Spearman) correlation coefficients with corresponding p-values were reported. To further investigate the relationships of subjective and objective severity with urodynamic urethral function measures, we formed quartiles for the urodynamic urethral function measures and used analysis of variance (ANOVA) to test the association of the other measures with the urethral function measures. To investigate the relationships between the urodynamic severity measures and the supine SEBST, separate ANOVA models were fit for each of the measures of severity with SEBST. Adjusted mean values by SEBST category for each variable were calculated with a corresponding p-value (Wilcoxon test used for non-normally distributed data).

Statistical analysis was performed using SAS Version 9.2 (SAS Institute, Inc., Cary, NC). A 5% two-sided significance level was used for all statistical testing. In general, correlation coefficients were described as: 0–0.1 little or no, 0.1–0.3 weak, 0.3–0.7 moderate, and 0.7–1.0 high. (<http://www.visualstatistics.net>)

Results

Five hundred and ninety seven women were randomly assigned to retropubic or transobturator mid-urethral sling procedures between April, 2006 and June, 2008. Mean ($\pm$ SD) age was 53 (11) with a range of 25 to 87 years. Seventy nine percent were Caucasian, 12% Hispanic, 3% African- American, and mean BMI was 30.4(6.8). Table I displays the mean values and ranges for both the subjective and objective severity measures. Although all subjects had predominant stress incontinence a vast majority (553/597,93%) had at least one positive response to a MESA urge question and could be considered to have mixed incontinence. Forty eight percent (287/595) exhibited a positive SEBST. Valid VLPP measurements were obtained in 62% (372/597) of participants; 9% had invalid or non-plausible pressure measures^{9, 10} and 29% did not leak with the Valsalva maneuver during urodynamics. The mean baseline P_{ves} for these standing subjects was 36 cm H₂O and the VLPP's had a mean value of 119 (42) cm/H₂O above atmospheric pressure. Valid MUCP and FUL measurements were obtained in 90% of subjects with means ($\pm$ SD) of 68 (32) cm H₂O and 32 (8) mm, respectively.

Figure 1 demonstrates the scatterplot relationships and regression lines of the three different urodynamic measures with each other. Although the linear regression models demonstrated a positive statistically significant linear relationship for all three associations, less than 9% of the variation in one measure could be explained by the other for all relationships.

The relationships between all the measures of incontinence severity are shown in Table II. The subjective measures of severity (MESA-S, UDI-S, IIQ) had weak to moderate correlation with each other ($r=0.25$ to 0.43). The objective measures (PW and IEF) also had moderate correlation ($r=0.53$, $p<0.001$) with each other and the major urodynamic measures (VLPP and MUCP) had moderate correlation with each other ($r=0.36$, $p<0.001$). The subjective measures of severity had mostly moderate correlation with the objective measures of severity ($r =0.06$ to 0.45). However, the urodynamic measures of urethral function(VLPP,

MUCP, and FUL) had little or no correlation with any subjective ($r=-0.13$ to 0.04) or objective ($r=-0.06$ to 0.02) measure of severity.

Although the urodynamic variables in our study followed a normal bell-shaped frequency distribution, it is common in the urodynamic literature to report results with cut-off values. Therefore, to determine if there were any threshold effects for urodynamic variables, we stratified VLPP and MUCP into their respective quartiles and evaluated all the above subjective and objective severity measure results for each quartile. There were no clinically meaningful subjective or objective severity measure differences between the 1st and 4th quartile of VLPP or MUCP measures (data not shown). To investigate the relationships between the UI severity measures and the SEBST separate linear regression models were fit for each of the subjective and objective measures of severity (Table III). With the exception of the UDI, the subjective measures of severity (MESA total, MESA-stress subscale, IIQ) had significantly larger mean or median scores in those subjects with a positive SEBST compared to those with a negative SEBST, although only the difference in the IIQ may be clinically meaningful. The objective measures of severity (PW and IEF) had a significantly larger median values in those subjects with a positive SEBST compared to those with a negative SEBST and these differences are clinically meaningful. There is no difference in mean FUL, MUCP, or VLPP values between those subjects with a positive and negative SEBST.

Finally, we investigated the relationship between SEBST and VLPP and MUCP values using cut-off values. Thirty-two percent of women with a positive SEBST had a VLPP <90 cm H₂O compared to 23% of women with a negative SEBST but this did not reach significance ($p=0.06$). Furthermore, there were no differences in the percentage of women with a positive SEBST in each VLPP quartile ($p=0.27$). Similar findings were noted for MUCP values dichotomized at 30 cm H₂O ($p=0.56$) and 40 cm H₂O ($p=0.11$) or by quartiles ($p=0.13$).

Discussion

In this large cohort of women scheduled to undergo surgery for SUI, traditional urodynamic measures of urethral function (VLPP, MUCP, and FUL) had little or no correlation with subjective or objective measures of incontinence severity. Our study results suggest that urodynamic measures of urethral function do not correlate with patient perception of bother, severity, or impact on quality of life.

Although the urodynamic measures did not correlate with severity, the non-urodynamic measures of urinary incontinence severity performed better. Our objective measures (PW and IEF) had moderate correlation with each other confirming other reports that pad weight and IEF have moderate to strong correlations with each other.^{15, 16} Similar to previous studies we also found that subjective measures of severity had weak to moderate correlation with each other and with the objective measures of severity. Our results confirm the SISTER trial results which showed a moderate correlation between total MESA score and pad weight ($r=0.33$) and IEF ($r=0.37$).⁴ Lowenstein et al¹⁷ found that the UDI correlated strongly with IEF on 7-day bladder diary, and Karantanis et al¹⁸ found a strong correlation between the International Consultation on Incontinence Questionnaire – Short Form and PW.

When comparing subjects with a positive and negative SEBST, no differences were demonstrated for VLPP, MUCP, or FUL, but there were statistically and clinically significant differences for PW, IEF, and IIQ scores. Our data suggests the SEBST may be a better indicator of severe stress incontinence than urodynamic testing. More importantly these results underscore the limited utility of currently available urodynamic parameters for

distinguishing between mild and severe SUI. The failure to detect a meaningful correlation between subjective and objective measures and urodynamic indices commonly associated with incontinence severity indicates the poor sensitivity of available urodynamic measures for identifying severe stress incontinence. Furthermore this study and results from our SISTER trial¹⁰ suggest that approximately 25% of women with demonstrable stress incontinence will not leak with Valsalva efforts during UDS, thereby limiting this measures ability to characterize a stress incontinent population.

Previous studies report mixed results correlating subjective and objective incontinence severity measures and urethral function measures Stach-Lempinen et al¹⁹ found that MUCP and SUI threshold (a proxy for VLPP) weakly correlated with patient reported urinary incontinence severity using a visual analog scale (VAS). However, similar to our results, they found that PW and IEF had a stronger correlation than UDS measures with incontinence severity on the VAS.¹⁹ Theofrastous et al³ found a moderate correlation between VLPP and PW and a weakly negative correlation between MUCP and IEF.

In contrast, Nager et al²⁰ found little or no correlation between VLPP or MUCP and PW and Chen et al²¹ found no correlation between LPP and IEF, UDI or IIQ scores. In the SISTER trial, 655 women underwent standardized filling cystometry and VLPP determinations (but not UPP studies) prior to surgical correction of stress incontinence and VLPP had little or no correlation with other incontinence severity measures.⁴

Similarly, urodynamic measures of urethral function did not predict which women would demonstrate the sign of stress incontinence on an empty supine stress test, or looking at it the other way; the empty bladder stress test did not predict low VLPP or low MUCP. In this study, only 21% of women with a positive empty supine stress test had an MUCP ≥ 40 cm H₂O and 32% a VLPP ≥ 90 cm H₂O. The mean VLPP was only 3 cm H₂O lower in subjects with a positive SEBST. These results confirm our earlier findings from the SISTER trial which showed only a 10 cm difference in mean VLPP measures between the positive and negative SEBST groups.⁴ Inclusion and exclusion criteria between this study and the SISTER trial differed slightly, which may contribute to these minor numerical differences. Our findings differ from those of Lobel and Sand²² who found that 66% of subjects with a positive SEBST had an MUCP > 20 cm H₂O and 76% with a negative SEBST had an MUCP > 20 cm H₂O. Their SEBST was performed within 20 min after catheterizations and microtip transducers were used for MUCP measures. MUCPs obtained by water perfusion methods have been reported to be 24 cm H₂O higher than microtip measures.²³ Our findings agree with the study by McLennan and Bent⁵ who found no statistically significant relationship between a positive SEBST and a low MUCP. McLennan and Bent did find that a negative SEBST was 95% predictive of a LPP > 60 cm H₂O but this was based on only 19 of 20 subjects less than 50 years of age. They measured their LPP as the increase in vesical pressure over resting pressure. Their 60 cm cut-off should be similar to our 90 cm cut-off which used atmospheric pressure as the baseline because typical bladder resting pressures in the standing position are approximately 30 cm H₂O.¹⁰ Although a positive empty supine stress test was generally associated with higher MESA and IIQ scores, the difference in MESA scores was only 1 point, suggesting that an empty supine stress test is not an optimal measure of subjective incontinence severity.

In this study VLPP, FUL, and MUCP had moderate correlation with each other suggesting that they do measure related aspects of urethral function. Microtip MUCP and VLPP correlations have ranged in the literature from 0.31 to 0.62.^{24–26} but with water perfusion MUCP's one study found a correlation of 0.50²⁰ while another reported no correlation.²⁷

The strength of this study include the large number of women with stress incontinence undergoing urodynamic techniques and interpretations that were standardized and validated.^{9, 10, 13} Our study only included women seeking surgical care for their incontinence and the mean age, parity, and BMI are representative of women undergoing stress incontinence surgery, but this group may not be representative of all women with stress incontinence and different correlations could be obtained if women with less severe incontinence not requesting surgical treatment were included. More important than whether urodynamic measures predict severity is whether they can predict success. In the SISTER trial, preoperative VLPP was not predictive of surgical outcome in either the sling or the Burch treatment groups.²⁸

Conclusions

This analysis of baseline data from a large population of women undergoing surgical correction of SUI suggests that common urodynamic measures of urethral function do not distinguish patients' preoperative perceptions of incontinence severity, quality of life impact, or objective measures of leakage. The role of urodynamics and urodynamic measures of urethral function do not seem to predict baseline incontinence severity; however, their role in predicting surgical outcomes needs further investigation.

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References

1. Nitti VW, Combs AJ. Correlation of Valsalva leak point pressure with subjective degree of stress urinary incontinence in women. *J Urol*. 1996; 155:281–5. [PubMed: 7490856]
2. Cummings JM, Boullier JA, Parra RO, et al. Leak point pressures in women with urinary stress incontinence: correlation with patient history. *J Urol*. 1997; 157:818–20. [PubMed: 9072575]
3. Theofrastous JP, Bump RC, Elser DM, et al. Correlation of urodynamic measures of urethral resistance with clinical measures of incontinence severity in women with pure genuine stress incontinence. The Continence Program for Women Research Group. *Am J Obstet Gynecol*. 1995; 173:407–12. discussion 12–4. [PubMed: 7645615]
4. Albo M, Wruck L, Baker J, et al. The relationships among measures of incontinence severity in women undergoing surgery for stress urinary incontinence. *J Urol*. 2007; 177:1810–4. [PubMed: 17437826]
5. McLennan MT, Bent AE. Supine empty stress test as a predictor of low valsalva leak point pressure. *Neurourol Urodyn*. 1998; 17:121–7. [PubMed: 9514144]
6. UITN. The Trial of Mid-Urethral Slings (TOMUS) Design and methodology. *J App Res*. 2008:1–13.
7. Herzog AR, Diokno AC, Fultz NH. Urinary incontinence: medical and psychosocial aspects. *Annu Rev Gerontol Geriatr*. 1989; 9:74–119. [PubMed: 2514773]
8. Shumaker SA, Wyman JF, Uebersax JS, et al. Health-related quality of life measures for women with urinary incontinence: the Incontinence Impact Questionnaire and the Urogenital Distress Inventory. Continence Program in Women (CPW) Research Group. *Qual Life Res*. 1994; 3:291–306. [PubMed: 7841963]
9. Nager CW, Albo ME, Fitzgerald MP, et al. Process for development of multicenter urodynamic studies. *Urology*. 2007; 69:63–7. discussion 7–8. [PubMed: 17270617]
10. Nager CW, Albo ME, Fitzgerald MP, et al. Reference urodynamic values for stress incontinent women. *Neurourol Urodyn*. 2007; 26:333–40. [PubMed: 17315221]
11. Abrams P, Cardozo L, Fall M, et al. The standardisation of terminology in lower urinary tract function: report from the standardisation sub-committee of the International Continence Society. *Urology*. 2003; 61:37–49. [PubMed: 12559262]
12. Schafer W, Abrams P, Liao L, et al. Good urodynamic practices: uroflowmetry, filling cystometry, and pressure-flow studies. *Neurourol Urodyn*. 2002; 21:261–74. [PubMed: 11948720]
13. Zimmern P, Nager CW, Albo M, et al. Interrater reliability of filling cystometrogram interpretation in a multicenter study. *J Urol*. 2006; 175:2174–7. [PubMed: 16697832]
14. Griffiths D, Hofner K, van Mastrigt R, et al. Standardization of terminology of lower urinary tract function: pressure-flow studies of voiding, urethral resistance, and urethral obstruction. International Continence Society Subcommittee on Standardization of Terminology of Pressure-Flow Studies. *Neurourol Urodyn*. 1997; 16:1–18. [PubMed: 9021786]
15. Elser DM, Fantl JA, McClish DK. Comparison of “subjective” and “objective” measures of severity of urinary incontinence in women. Program for Women Research Group. *Neurourol Urodyn*. 1995; 14:311–6. [PubMed: 7581467]

16. Groutz A, Blaivas JG, Chaikin DC, et al. Noninvasive outcome measures of urinary incontinence and lower urinary tract symptoms: a multicenter study of micturition diary and pad tests. *J Urol*. 2000; 164:698–701. [PubMed: 10953128]
17. Lowenstein L, Kenton K, FitzGerald MP, et al. Clinically useful measures in women with mixed urinary incontinence. *Am J Obstet Gynecol*. 2008; 198:664, e1–3. discussion e3–4. [PubMed: 18538148]
18. Karantanis E, Fynes M, Moore KH, et al. Comparison of the ICIQ-SF and 24-hour pad test with other measures for evaluating the severity of urodynamic stress incontinence. *Int Urogynecol J Pelvic Floor Dysfunct*. 2004; 15:111–6. discussion 6. [PubMed: 15014938]
19. Stach-Lempinen B, Kirkinen P, Laippala P, et al. Do objective urodynamic or clinical findings determine impact of urinary incontinence or its treatment on quality of life? *Urology*. 2004; 63:67–71. discussion -2. [PubMed: 14751350]
20. 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. [PubMed: 11795644]
21. Chen CC, Rooney CM, Paraiso MF, et al. Leak point pressure does not correlate with incontinence severity or bother in women undergoing surgery for urodynamic stress incontinence. *Int Urogynecol J Pelvic Floor Dysfunct*. 2008; 19:1193–8. [PubMed: 18414765]
22. Lobel RW, Sand PK. The empty supine stress test as a predictor of intrinsic urethral sphincter dysfunction. *Obstet Gynecol*. 1996; 88:128–32. [PubMed: 8684745]
23. Wang AC, Chen MC. A comparison of urethral pressure profilometry using microtip and double-lumen perfusion catheters in women with genuine stress incontinence. *BJOG*. 2002; 109:322–6. [PubMed: 11950188]
24. McLennan MT, Melick CF, Bent AE. Leak-point pressure: clinical application of values at two different volumes. *Int Urogynecol J Pelvic Floor Dysfunct*. 2000; 11:136–41. [PubMed: 11484740]
25. Swift SE, Ostergard DR. A comparison of stress leak-point pressure and maximal urethral closure pressure in patients with genuine stress incontinence. *Obstet Gynecol*. 1995; 85:704–8. [PubMed: 7724100]
26. Sultana CJ. Urethral closure pressure and leak-point pressure in incontinent women. *Obstet Gynecol*. 1995; 86:839–42. [PubMed: 7566860]
27. McGuire EJ, Fitzpatrick CC, Wan J, et al. Clinical assessment of urethral sphincter function. *J Urol*. 1993; 150:1452–4. [PubMed: 8411422]
28. Nager CW, FitzGerald M, Kraus SR, et al. Urodynamic measures do not predict stress continence outcomes after surgery for stress urinary incontinence in selected women. *J Urol*. 2008; 179:1470–4. [PubMed: 18295276]

Figure 1. Scatterplot of (a) VLPP vs. MUCP, (b) VLPP vs. FUL and (c) MUCP vs. FUL with regression line. See Table I for abbreviations.

Table I**Baseline Urinary Incontinence Severity Measures**

Variable	N	Mean (SD)	Range
Medical Epidemiological and Social Aspects of Aging (MESA) - total	597	26(8)	3–44
MESA-Stress	597	19(5)	3–27
Urogenital Distress Inventory (UDI) - total	597	135(46)	17–283
UDI-Stress	597	74(22)	0–100
Incontinence Impact Questionnaire (IIQ)	597	152(97)	0–400
Pad Weight (PW) ^a (g)	594	12.5 (6.0–33.5)	0–546
Incontinence Episode Frequency (IEF) ^a (leaks/day)	593	2.7 (1.3–4.7)	0–26
Valsalva Leak Point Pressure (VLPP) (cm H ₂ O)	372	119(42)	25–266
Maximum Urethral Closure Pressure (MUCP) (cm H ₂ O)	539	68(33)	10–246
Functional Urethral Length (FUL)(mm)	539	32(8)	10–50

^aPW and IEF are presented with median and interquartile range since they are not normally distributed.

Table II

Correlation coefficients for Subjective, Objective, and Urodynamic measures of severity (p-values in parentheses). See Table I for abbreviations.

	Subjective (Subj)			Objective (Obj)			Urodynamic (UDS)		
	MESA-S	UDI-S	IIQ	PW	IEF	VLPP	MUCP		
Subj	UDI-S	0.28 (<0.001)							
	IIQ	0.43 (<0.001)	0.25 (<0.001)						
Obj	PW	0.35 (<0.001)	0.06 (0.18)	0.31 (<0.001)					
	IEF	0.45 (<0.001)	0.17 (<0.001)	0.34 (<0.001)	0.53 (<0.001)				
	VLPP	-0.13 (0.01)	-0.09 (0.10)	0.02 (0.66)	-0.06 (0.23)	-0.09 (0.08)			
UDS	MUCP	-0.11 (0.01)	-0.07 (0.13)	0.01 (0.87)	-0.04 (0.40)	-0.03 (0.52)	0.36 (<0.001)		
	FUL	-0.05 (0.26)	0.04 (0.31)	-0.05 (0.29)	-0.06 (0.14)	-0.02 (0.69)	0.20 (<0.001)		
								0.13 (0.002)	

Severity measures grouped by supine empty bladder stress test (SEBST) results. See Table I for abbreviations.

Table III

Variable	SEBST(N=594)				p-value
	Positive(N=285)		Negative(N=309)		
	N	Mean(SD)	N	Mean(SD)	
MESA total	285	26(8)	309	25(8)	0.005
MESA-S	285	20(4)	309	19 (5)	<0.001
UDI total	285	137(45)	309	132(46)	0.23
UDI-S	285	75(21)	309	74 (22)	0.32
IIQ	285	163(102)	309	142(93)	0.008
PW ^a	284	16.0(6.9–46.1)	307	9.8(5.3–28.3)	<0.001
IEF ^a	283	3.0(1.7–5.0)	307	2.3(1.0–4.0)	<0.001
FUL	249	31(8)	287	32(8)	0.31
MUCP	249	67(36)	287	69(30)	0.69
VLPP	193	118 (45)	176	121(40)	0.58

^aPW and IEF were presented with median and interquartile range, and both p-values come from Wilcoxon test.