Validation of ultrasound scan in the diagnosis of female stress urinary incontinence

A. Lukanovič[1], T.S. Patrelli[1, 2]

[1]*Department of Obstetrics and Gynaecology, University Medical Center Ljubljana (Slovenia)*
[2]*Department of Obstetrics and Gynaecology, University Medical Center Parma (Italy)*

Summary

Objective: To validate transperineal ultrasound (US) in the assessment of urethrovesical junction hypermobility. *Methods:* In this prospective study carried out between 1999 and 2003 at a university medical centre we enrolled 100 women with genuine stress urinary incontinence (study group) and 50 continent women (control group). All women underwent the diagnostic protocol including urodynamic measurement and transperineal US scan using an abdominal semicircular 3.5 MHz linear array transducer. The position of the urethrovesical junction was described in relation to the inferior edge of the symphysis pubis by two parameters: the cephalocaudal and the ventrodorsal distance. The position and degree of urethrovesical junction descent during stress (3 consecutive coughs) were measured and the results compared between the groups. Classification performance was evaluated by sensitivity and specificity. *Results:* There was no significant difference in the horizontal plane of the urethrovesical junction at rest and in the backward displacement during stress between the groups. The downward displacement of the urethrovesical junction showed an average descent of 16.10 ± 4.01 mm in the study group vs 7.92 ± 2.85 mm in the control group; the difference between the groups was statistically significant ($p = 0.001$). Considering the 12 mm cut-off value of the descent, US evaluation had an 88% specificity, and a 92% sensitivity; the PPV and NPV were 96 % and 79 %, respectively. *Conclusions:* We found a significantly greater downward displacement of the urethrovesical junction during stress in women with stress urinary incontinence compared to healthy controls. We may conclude that transperineal US can accurately visualise a hypermobile urethrovesical junction.

Key words: Female stress urinary incontinence; Bladder neck hypermobility; Ultrasound evaluation.

Introduction

Urinary incontinence is one of the most frequent diseases in the female population. Among various types of female urinary incontinence, the incidence of stress urinary incontinence is the highest by far [1, 2].

Due to the rational diagnostic approach, diagnostic ultrasonography [3-5] has become more frequently used in the morphologic diagnosis of anatomic changes of the pelvic floor.

Ultrasound (US) examination is inexpensive, harmless and well tolerated by patients, and reduces the need for conventional radiography [6].

One of the most frequent causes of female stress urinary incontinence is hypermobility of the bladder neck and proximal urethra. Hypermobility is the result of a defect of the anatomic supporting structures of the proximal urethra [7].

Although tape procedures are currently used all over the world as primary operations, the suprapubic approach is the gold standard for surgical treatment of female stress urinary incontinence. Surgical suspension of the bladder neck and the proximal urethra represents the indirect fixation of the weakened endopelvic fascia [8].

Numerous modes of diagnostic US examinations have been used in urogynecology: abdominal, rectal, vaginal, introital and perinea [l9-13]. Since 1986, when the first reports on the use and advantages of perineal US were published, this mode of diagnostic US examination has become the method of choice in clinical practice [14, 15].

The advantages of perineal US are the following:

- the US probe does not interfere with the mobility of the anterior vaginal wall and the bladder neck during the measurement at stress;
- the US probe does not change its position during cough or the Valsalva manoeuvre;
- the examination provides a good topographic anatomic picture of the bladder base and bladder neck, the urethra and symphysis.

The aim of this study was to evaluate the use of perineal US in preoperative diagnosis of female stress urinary incontinence, and to find whether the evaluation of the changed position of the bladder neck during cough is a useful and reliable diagnostic method for deciding on the surgical treatment of female stress urinary incontinence.

Methods

Study Population

The study was performed at the Department of Obstetrics and Gynecology in Ljubljana between 1999 and 2003, after approval by the national medical ethics committee. We enrolled 150 patients who had agreed to participate in the study by signing the informed consent form. The study group consisted of 100 women with clinically and urodynamically proven stress urinary incontinence and the control group of 50 continent women.

Revised manuscript accepted for publication May 31, 2011

Method

The women in both groups underwent standard urodynamic measurements used in the diagnosis of stress urinary incontinence and perineal US scan.

To evaluate urethrovesical junction mobility and position transperineal US was performed using a Toshiba Diagnostic Ultrasound System SSA 250 and a semi-circular linear 3.75 MHz abdominal probe. The probe was placed on the sagittal axis of the perineum after the woman was placed in the supine position with the urinary bladder filled with 300 ml of physiological saline warmed to body temperature. The scan of the symphysis pubis, bladder, urethrovesical junction and urethra at rest was followed by the scan during cough. The images were frozen for evaluation of the bladder neck and bladder base descent.

The distance from the bladder neck in the horizontal and vertical planes to the reference point, set at the lower edge of the symphysis, was measured and expressed in mm. The distance was assessed at rest and during cough, and mean values were calculated.

Statistical analysis

Data were analysed with SPSS software version 16.0 (SPSS, Chicago, IL, USA). Numeric variables are presented as the mean ± standard deviation (SD). To assess differences between continuous variables the Student's t-test and Mann-Whitney-U test were used according to the normality of the variable in question. Chi-square tests were used to compare categorical data; $p < 0.05$ was considered statistically significant.

Specificity and sensitivity of the US method were determined. For the calculation of positive and negative predictive values the prevalence of stress urinary incontinence in the population was assumed to be 25%. Classification performance was evaluated by the area under ROC curve.

Results

Data on age, parity, menopausal status and type of work were obtained from all the women enrolled in the study.

The mean age of women was 46.2 ± 8.5 years in the study group, and 53.8 ± 10.9 years in the control group; the difference was statistically significant ($p < 0.001$, t-test).

The mean number of deliveries was 1.98 in the study group, and 1.64 in the control group; the difference was not statistically significant ($p = 0.053$, Mann-Whitney test).

As for menopausal status, 74 (74%) women in the study group and 16 (32%) women in the control group were menopausal; the difference was statistically significant ($p < 0.001$, χ^2 test).

Heavy work was performed by 66 (66%) women in the study group and 24 (48%) women in the control group; the difference was statistically significant ($p = 0.034$, χ^2 test).

In the present study the position of the urethrovesical junction was analysed using transperineal US in 100 women with confirmed stress urinary incontinence compared to 50 healthy controls. We measured the distance between the urethrovesical junction and the inferior edge of the symphysis pubis (X distance) and the distance between the urethrovesical junction and the vertical plane of the front edge of symphysis pubis (Y distance). Mean values of the distances X and Y are presented in Tables 1 and 2.

Table 1. — *Mean values of X and Y distances at rest and during coughing in both groups.*

Distance	Rest Mean ± SD	Coughing Mean ± SD	Displacement Mean ± SD
Study group			
X distance (mm)	22.24 ± 6.57	28.56 ± 6.33	6.32 ± 2.4
Y distance (mm)	20.55 ± 5.68	36.39 ± 6.75	16.10 ± 4.01
Control group			
X distance (mm)	23.60 ± 4.98	30.36 ± 5.74	6.76 ± 3.07
Y distance (mm)	25.98 ± 5.14	33.70 ± 5.31	7.92 ± 2.85

Table 2. — *Mean displacement of X and Y distances - comparison between the study and the control group.*

Distance	Study group Mean ± SD	Control group Mean ± SD	Stat. significance *p*
X distance difference (mm)	6.32 ± 2.4	6.76 ± 3.07	0.37
Y distance difference (mm)	16.10 ± 4.01	7.92 ± 2.85	< 0.001

Mean distances of the bladder neck at rest in the horizontal plane with regard to the reference point, i.e., the lower edge of the symphysis, did not differ significantly between the groups. However, in the vertical plane the difference of mean distances at rest was statistically significant, being 16.10 ± 4.01 mm in the study group and 7.92 ± 2.85 mm in the control group ($p < 0.01$). The comparison of mean values of the displacement of the bladder neck at increased intraabdominal pressure during cough in the horizontal plane did not reveal significant differences between the groups.

Sensitivity and specificity

Statistical analysis of the US measurements of bladder neck mobility during cough in the study group showed the method to have a sensitivity of 64% and a specificity of 96%, considering the descent of the bladder neck for 15 mm as physiologic. If this cut-off value was reduced to 12 mm, the sensitivity of the method increased to 88%, and specificity decreased to 92%.

Sensitivity and specificity according to the cut-off value are presented in Figure 3.

Figure 4 presents the performance of US measurement in the diagnosis of stress urinary incontinence by means of ROC curves. The area under the curve is 0.952 (95% confidence interval 0.904-0.980).

Predictive values

Predictive value of the method is influenced by the cut-off value considering the change of the bladder neck position during cough as physiologic. Positive and negative predictive values were calculated at the cut-off value 12

Fig. 1

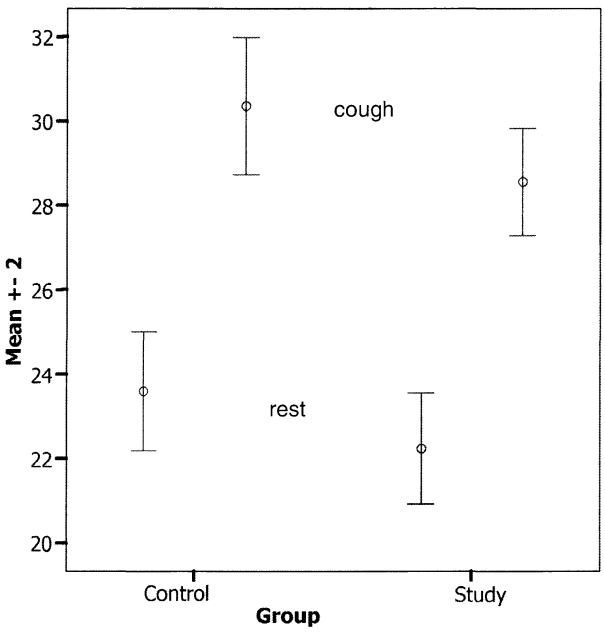

Fig. 2

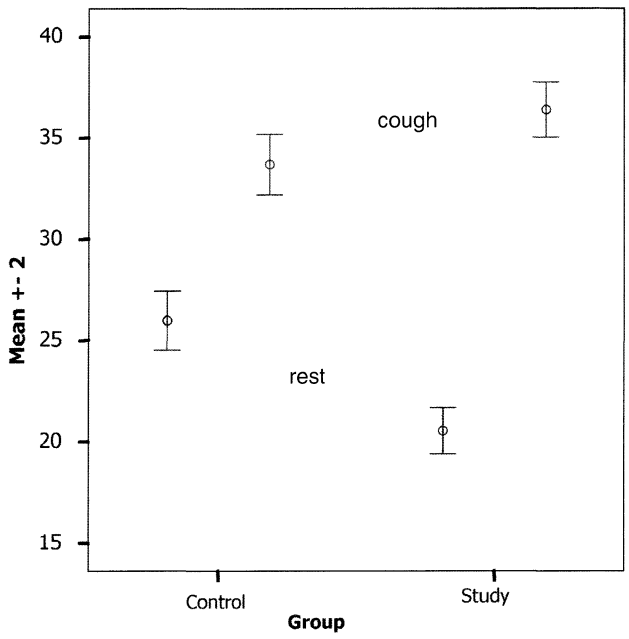

Fig. 3

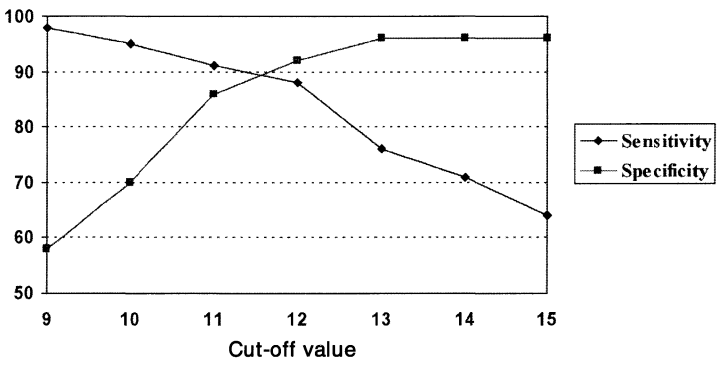

Fig. 4

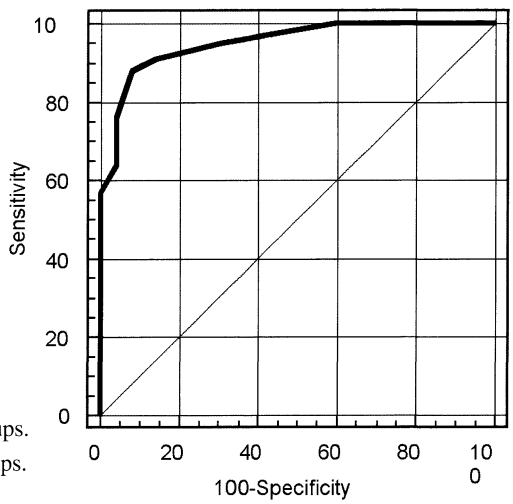

Figure 1. — X distance measurements at rest and during coughing in both groups.

Figure 2. — Y distance measurements at rest and during coughing in both groups.

Figure 3. — Sensitivity and specificity according to the cut-off value.

Figure 4. — Performance of ultrasound measurement in the diagnosis of stress urinary incontinence by means of ROC curves. The area under the curve is 0.952 (95% confidence interval 0.904-0.980).

mm. A prevalence of stress urinary incontinence in the screened population was assumed to be 25%.

The calculated positive predictive value (PPV) was 57% and the calculated negative predictive value (NPV) was 98%. If the cut-off value was decreased to 10 mm, the PPV increased to 76%, whereas the NPV was 95%.

Discussion

The suprapubic suspension of the bladder neck has been increasingly used in the surgical treatment of female stress urinary incontinence. Therefore, it is evident that the prevailing theory in clinical practice is that hypermobility of the bladder neck is the main cause for the occurrence of stress urinary incontinence. In spite of favourable outcomes of retropubic surgeries, 10-15% of women still experience problems with urinary leakage after surgery [16]. It is not quite evident whether this is the consequence of a failed surgical suspension of the bladder neck or of an inappropriately chosen mode of treatment, i.e., of undiagnosed unstable detrusor, or due to newly made noninhibited detrusor contractions following surgery. In the diagnosis of stress urinary incontinence, and especially before deciding on a surgical treatment, it is indispensable to find and prove the changes in the supporting structures of the bladder neck and of the proximal urethra. Numerous morphologic examinations and tests aim at assessing pathoanatomical changes of the pelvic floor. However, clinical practice requires a simple, reproducible, quick and inexpensive test that would provide a

more reliable diagnosis, and serve as the basis for the decision on a proper surgical technique with an efficient outcome. For their invasiveness, radiological methods have been losing their impact in the diagnosis of stress urinary incontinence [17, 18]. Using real-time imaging, diagnostic US has changed the approaches from abdominal, rectal and vaginal to finally find the most advantageous approach, the perineal approach, which has been proven to provide the best morphological assessment of hypermobility of the bladder neck and of the proximal urethra [19-22].

In this study we analyzed clinical applicability of diagnostic perineal US, and determined the specificity and sensitivity of the method. The assessment involved mean distances of the bladder neck with regard to the reference point, i.e., the lower edge of the symphysis at rest women with clinically and urodynamically proven stress urinary incontinence in comparison to the distances obtained from continent women. Then, the displacement of the bladder neck with regard to the reference point was measured during cough and again the results were compared between the two groups. We found that mean distances **X** (ventro-dorsal plane) did not differ significantly between the groups. However, the difference of the distance from the bladder neck to the lower edge of the symphysis at rest was statistically significant. We found significantly lower positions of the bladder neck in control group women. Demirci and Fine [23] provided a precise determination of the position of the bladder neck by measuring the displacement during cough in craniocaudal and ventrodorsal directions. The results obtained in this study are comparable to those by Johnson *et al.* [24]. They found the mean value of displacement of the bladder neck in the craniocaudal direction during cough to be 1.65 cm in women with stress urinary incontinence, and 0.32 cm in continent women. Shaer *et al.* [25] found the same values of the displacement of the bladder neck during cough, and considered the measurement in the craniocaudal direction to be sufficient for a preoperative diagnosis of stress urinary incontinence.

Due to increased intraabdominal pressure during cough, the descent of the bladder neck scanned in the craniocaudal direction is greater in incontinent than in continent women. In our study the descent was significantly greater in the study group than in the control group women in whom the position of the bladder neck was significantly lower at rest as well.

To provide the possibility of using perineal diagnostic sonography in clinical urogynecology, the method requires standardisation. We should define the maximal range of displacement of the urinary bladder during cough, still to be considered physiological. The first to suggest the critical limit of 10 mm was Bergman and colleagues [26], who then calculated the specificity of the method (89%) and its sensitivity. Caputo and Benson [27] chose the same limit (10 mm) as Bergman's group [26]. In our study we decided on the threshold value of 15 mm when assessing displacement of the bladder neck during cough. Using this threshold value the calculated sensitivity of the method reached only 64%. If this value was decreased to 12 mm, the sensitivity of the method increased to 88%. At a 15-mm displacement of the bladder neck, the specificity was 96%; if the threshold value was decreased to 12 mm, the specificity of the method was still 92%.

When we considered the measured values of the displacement of 15 mm and more as pathological, the statistical analysis provided a 100% NPV of this method. Predictive values show the agreement of the sonographic measurement with the diagnosis of stress urinary incontinence. The PPV at the threshold value of 15 mm was only 44%. If we considered the 12-mm value, the PPV reached 57%, whereas the NPV of the test remained almost unchanged, i.e., 98%. Furthermore, lowering the cut-off to 10 mm, we found the PPV to be 76% and the NPV 95%.

The mean age of women was significantly lower in the study group than that in the control group (46.1 ± 8.5 years vs 53.8 ± 10.8 years; $p < 0.01$)). In the study group only 26% of women were postmenopausal, and in the control group 68%. The difference between the groups was statistically significant. With regard to parity, we found no statistically significant difference between the study and control group women. The results of our study do not prove the influence of delivery on the occurrence of stress urinary incontinence. In the analysis of the incidence of stress urinary incontinence in nulliparas, Scott [28] found that 40% of women who have never delivered, experienced problems with urinary leakage.

However, we found a statistically significant difference in the type of work in both groups: 66% of women in the study group, and only 48% in the control group did hard physical work. A lower position of the bladder neck at rest in the control group women could be explained by the variables such as older age and age-related estrogen status. These features affect the function of the muscle connective structures of the supporting mechanism. Hypoestrogenemia results in reduced type III collagen production [29, 30]. Increased intraurethral pressure has been proven in women who had undergone estrogen treatment [31-33].

Although it is known that the weakness of the supportive structures of the urinary bladder and proximal urethra are the most evident reasons for the occurrence of stress urinary incontinence, the actual relationship between morphological and pathophysiological events remain unknown.

Enhorning [34] claimed that the proximal urethra is positioned intraabdominally and that the transmission of the increased intraabdominal pressure on the urethra is inappropriate when the urethra is displaced below the pelvic floor [35, 36]. As the intraurethral pressure is not increased stress urinary incontinence occurs. According to this theory, the position of the bladder neck determines continence. The studies made by Richardson *et al.* [37] have elucidated the reasons for continence in women with urethrocystocele, in whom the bladder neck is positioned low. Their studies have confirmed the importance of par-

avaginal fascia for urinary continence [38-40]. The proximal urethra lies on the support consisting of pubocervical fascia, anterior vaginal wall, arcus tendineus fascie pelvis and levator ani muscle. The effect of bilateral compression on the urethra depends on the stability of suburethral support and not on the position of the bladder neck [41]. If the support is firm, the proximal urethra presses against the support in case of increased intraabdominal pressure. In case of a weak support, the bilateral compression of the urethra is not sufficient and the transmission of intraabdominal pressure on the urethra is weaker; as the lumen of the urethra remains open, urinary leakage occurs. The extent of transmission of increased intraabdominal pressure does not depend on the high position of the bladder neck, because the firm support, which is responsible for continence, may also have a lower position [42-44].

Contractions of the detrusor can be quite efficiently assessed on real-time US scan using a probe that provides good resolution; the time lapse of the opening of the bladder neck and urinary leakage during cough is a warning for the physician that the diagnosis of stress urinary incontinence is unreliable. In this case, cystometry is required, because this is the only procedure to exclude the increase in the intravesical pressure for more than 15 cm of water during spontaneous contractions of the detrusor, which is necessary for the diagnosis of unstable detrusor and appropriate treatment of urinary incontinence.

Diagnostic US of the lower urinary tract has numerous advantages over radiological and morphological methods for the patient and the examiner. The diagnostic perineal approach combined with modern US equipment with good imaging resolution provides optimal scans of pathoanatomical changes of the pelvic floor.

Diagnostic perineal US scan is a simple, non-invasive, cost-effective, safe and reproducible method providing morphological assessment of hypermobility of the bladder neck and the proximal urethra. The method is well tolerated by the patients.

We found the perineal US examination to have the highest performance when the threshold value, still considered physiological, of the displacement of the bladder neck during cough was 12 mm. Taking this cut-off value into consideration, the method has an 88% sensitivity and a 92% specificity; the calculated PPV is then 96%, and the NPV 79%.

References

[1] Kralj B., Lazarevski M.: "Ginekološka urologija". In: Ginekologija i perinatologija, Kurjak A (ed.). Golden Times: Varaždinske Toplice, 1995, 439.

[2] Kralj B.: "Epidemiology of female urinary incontinence, classification of urinary incontinence, urinary incontinence in elderly women". *Eur. J. Obstet. Gynecol. Reprod. Biol.*, 1994, *55*, 39.

[3] Fischer W.: "Epidemiologie der Harninkontinenz". In: Fischer W., Kolbl H. (eds.). Urogynaekologie in Praxis und Klinik, Berlin, Walter de Gruyter, 1995, 192.

[4] Ghoniem G.M., Shoukry M.S., Yang A., Mostwin J.L.: "Imaging for urogynecology, including new modalities". *Int. Urogynecol. J.*, 1992, *3*, 212.

[5] Reddy A.P., DeLancey J.O., Zwica L.M., Ashton-Miller J.A.: "On-screen vector-based ultrasound assessment of vesical neck movement". *Am. J. Obstet. Gynecol.*, 2001, *185*, 165.

[6] Kurjak A.: "Atlas of ultrasonography in Obstetrics and Gynecology". Zagreb, Mladost, 1986.

[7] Summitt R.L. Jr., Bent A.E.: "Genuine stress incontinence: an overview". In: Ostergard D.R., Bent A.E. (eds.). Urogynaecology and Urodynamics. Theory and Practice, 4th edition. Williams & Wilkins, Baltimore, London, Los Angeles, 1996, 493.

[8] Bernaschek G., Deutinger J., Kratochwil A.: "Diagnostic evaluation of urinary incontinence". In: Bernaschek G., Deutinger J., Kratochwill A. (eds.). Endosonography in Obstetrics and Gynecology, Springer-Verlag: Berlin, Heidelberg, New York, 1990, 123.

[9] Richmond D.H., Sutherst J.: "Transrectal ultrasound scanning in urinary incontinence: the effect of the probe on urodynamic parameters". *Br. J. Urol.*, 1989, *64*, 582.

[10] Weil E.H., van Waalwijk van Doorn E.S., Heesakkers J.P., Meguid T., Janknegt R.A.: "Transvaginal ultrasonography: a study with healthy volunteers and women with genuine stress incontinence". *Eur. Urol.*, 1993, *24*, 226.

[11] Quinn M.J.: "Vaginal ultrasound and urinary stress incontinence". *Contemp. Rev. Obstet. Gynaecol.*, 1990, *2*, 104.

[12] Hol M., van Bolhuis C., Vierhout M.E.: "Vaginal ultrasound studies of bladder neck mobility". *Br. J. Obstet. Gynaecol.*, 1995, *102*, 47.

[13] Beco J., Sulu M., Schaaps J.P., Lambotte R.: "A new approach to urinary continence disorders in women: urodynamic ultrasonic examination by the vaginal route". *J. Gynecol. Obstet. Biol. Reprod.*, 1987, *16*, 987.

[14] Wise B., Cutner A., Cardozo L., Abbott D., Burton G.: "The assessment of bladder neck movement in postpartum women using perineal ultrasonography". *Ultrasound Obstet. Gynecol.*, 1992, *2*, 116.

[15] Dietz H.P.: "Ultrasound imaging of the pelvic floor. Part II: three-dimensional or volume imaging". *Ultrasound Obstet. Gynecol.*, 2004, *23*, 615.

[16] DeLancey J.O., Cullen Richardson A.: "Anatomy of genital support". In: Hurt G.W. (ed.). Urogynecologic Surgery, Raven Press, New York, 1992, 19.

[17] Koelbl H.: "Ultrasound in urogynecology". In: Ostergard D.R., Bent A.E. (eds.). 4th edition. Urogynecology and Urodynamics. Theory and practice, Williams & Wilkins: Baltimore, London, Los Angeles, 1996, 213.

[18] Enzelsberger H., Schatten C., Kurz C., Fitzal P.: "Urodynamic and radiologic parameters before and after loop surgery for recurrent urinary stress incontinence". *Acta Obstet. Gynecol. Scand.*, 1990, *9*, 51.

[19] Richmond D.H., Sutherst J.R.: "Clinical application of transrectal ultrasound for the investigation of the incontinent patient". *Br. J. Urol.*, 1989, *63*, 605.

[20] Mouritsen L., Rasmussen A.: "Bladder neck mobility evaluated by vaginal ultrasonography". *Br. J. Urol.*, 1993, *71*, 166.

[21] Kohorn E.I., Scioscia A.L., Jeanty P., Hobbins J.C.: "Ultrasound cystourethrography by perineal scanning for the assessment of female stress urinary incontinence". *Obstet. Gynecol.*, 1986, *68*, 269.

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

[23] Demirci F., Fine P.M.: "Ultrasonography in stress urinary incontinence". *Int. Urogynecol. J. Pelvic Floor Dysfunct.*, 1996, *7*, 125.

[24] Johnson J.D., Lamensdorf H., Hollander I.N., Thurman A.E.: "Use of transvaginal endosonography in the evaluation of women with stress urinary incontinence". *J. Urol.*, 1992, *147*, 421.

[25] Schaer G.N., Koechli O.R., Schuessler B., Haller U.: "Perineal ultrasound for evaluating the bladder neck in urinary stress incontinence". *Obstet. Gynecol.*, 1995, *85*, 220.

[26] Bergman A., Vermesh M., Ballard C.A., Platt L.D.: "Role of ultrasound in urinary incontinence evaluation". *Urology*, 1989, *33*, 443.

[27] Caputo R.M., Benson J.T.: "The Q-tip test and urethrovesical junction mobility". *Obstet. Gynecol.*, 1993, *82*, 892.

[28] Scott J.C.: "Stress incontinence in nulliparous women". *J. Reprod. Med.*, 1969, *2*, 96.
[29] Walters M.D., Jackson G.M.: "Urethral mobility and its relationship to stress incontinence in women". *J. Reprod. Med.*, 1990, *35*, 777.
[30] Falconer C., Ekman G., Malmström A., Ulmsten U.: "Decreased collagen synthesis in stress-incontinent women". *Obstet. Gynecol.*, 1994, *84*, 583.
[31] Elia G., Bergman A.: "Estrogen effects on the urethra: beneficial effects in women with genuine stress incontinence". *Obstet. Gynecol. Surv.*, 1993, *48*, 509.
[32] Fantl J.A., Cardozo L., McClish D.K.: "Estrogen therapy in the management of urinary incontinence in postmenopausal women: a meta-analysis. First report of the Hormones and Urogenital Therapy Committee". *Obstet. Gynecol.*, 1994, *83*, 12.
[33] Ulmsten U., Stormby N.: "Evaluation of the urethral mucosa before and after oestrogen treatment in postmenopausal women with a new sampling technique". *Gynecol. Obstet. Invest.*, 1987, *24*, 208.
[34] Enhorning G.: "Simultaneous recording of intravesical and intraurethral pressure. A study on urethral closure in normal and stress incontinent women". *Acta Chir. Scand. Suppl.*, 1961, *276*, 1.
[35] McGuire E.J.: "Active and passive factors in urethral incontinence function". *Int. Urogynecol. J.*, 1992, *3*, 54.
[36] DeLancey J.O.: "Structural aspects of the extrinsic continence mechanism". *Obstet. Gynecol.*, 1988, *72*, 296.
[37] Richardson D.A., Bent A.E., Ostergard D.R.: "The effect of uterovaginal prolapse on urethrovesical pressure dynamics". *Am. J. Obstet. Gynecol.*, 1983, *146*, 901.
[38] DeLancey J.O.L.: "Pubovesical ligament: A separate structure from the urethral supports (pubo-urethral ligaments)". *Neurourol. Urodynam.*, 1989, *8*, 53.
[39] DeLancey J.O.: "Structural support of the urethra as it relates to stress urinary incontinence: the hammock hypothesis". *Am. J. Obstet. Gynecol.*, 1994, *170*, 1713.
[40] DeLancey J.O.L.: "Anatomy of the female bladder and urethra". In: Ostergard D.R., Bent A.E. (eds.) Urogynecology and Urodynamics, 3rd edition. William & Wilkins, New York, London, 1991, 3.
[41] Boutteville C., Anidjar M., Crequat J., Boccon-Gibod L., Madelenat P.: "Urodynamic ultrasonography in the management of urinary disorders in women". *Contracept. Fertil. Sex,* 1993, *21*, 317.
[42] Gosling J.A., Dixon J.S., Critchley H.O., Thompson S.A.: "A comparative study of the human external sphincter and periurethral levator ani muscles". *Br. J. Urol.*, 1981, *53*, 35.
[43] DeLancey J.O.: "Anatomy and physiology of urinary continence". *Clin. Obstet. Gynecol.*, 1990, *33*, 298.
[44] DeLancey J.O., Starr R.A.: "Histology of the connection between the vagina and levator ani muscles. Implications for urinary tract function". *J. Reprod. Med.*, 1990, *35*, 765.

Address reprint requests to:
T.S. PATRELLI, M.D.
Department of Obstetrics, Gynecology and Neonatology
University Hospital of Parma
Antonio Gramsci, 14
43126 Parma (Italy)
e-mail: titosilvio.patrelli@gmail.com