Middle Black Sea Journal of Health Science /
Mid Blac Sea J Health Sci
December 2021; 7(3):312-319

RESEARCH ARTICLE
DOI: 10.19127/mbsjohs.911429

The Evaluation of Posterior Urethrovesical Angle, Urethral Length, Bladder Wall Thickness, and Residual Volume with Transperineal Ultrasonography in Women with Urinary Incontinence

Nihal Callioglu[1(ID)],Keziban Dogan[1(ID)], Cemal Ark[2(ID)],Sema Baghaki [1(ID)]

[1]Department of Obstetrics and Gynaecology. Sadi Konuk Research and Training Hospital,Istanbul,Turkey
[2]Department of Obstetrics and Gynaecology. Kanuni Sultan Süleyman Research and Training Hospital,Istanbul,Turkey.

Received: 01 May 2021, Accepted: 16 October 2021, Published online: 31 December 2021

Objective: In the recent decades, transperineal ultrasonography has been used to examine patients in urogynaecology practice. In this study, we aimed to evaluate the function of transperineal ultrasonography in women with urinary incontinence.
Methods: Forty-five patients who were admitted to our institution between December 2012 and May 2013 and clinically and urodynamically diagnosed as having urinary incontinence (SUI n=20, DI+UUI n=13, MUI n=12) were included in the study. Additionally, 25 clinically and urodynamically continent women were included as the control group.
The patients were evaluated using transperineal ultrasonography (USG) in the supine position during rest and straining. An abdominal probe was placed in the perineum vertically and sagittally; when the symphysis pubis, urethra, bladder, vagina, and rectum could be seen clearly on the monitor, the image was frozen. Posterior urethrovesical angle (PUVA), urethral length, bladder wall thickness, and residual urine volume were measured on the image. All measurements were compared statistically between the SUI, UUI, MUI groups, and control group. The post-void residual volume measured using transperineal ultrasonography was compared with the post-void residual volume measured using a catheter during urodynamics.
Results: PUVA was significantly different in the SUI and MUI groups at rest than in the control group ($p<0.05$). During Valsalva maneuvers, PUVA was statistically significantly different in the SUI and MUI groups than in the UUI and control groups ($p<0.01$).
Conclusion: The measurement of PUVA and bladder wall thickness by transperineal ultrasonography is shown to be useful in diagnosis of patients with suspected detrusor instability and structural defects in pelvic floor. Therefore, transperineal USG may be an easy and reliable method which could be an alternative to urodynamic studies in patients who cannot undergo urethral catheterization.
Key words: urinary incontinence, ultrasonography, urinary sphincter

Suggested Citation: Callioglu N, Dogan K, Ark C, Baghaki S. The Evaluation of Posterior Urethrovesical Angle, Urethral Length, Bladder Wall Thickness, and Residual Volume with Transperineal Ultrasonography in Women with Urinary Incontinence. Mid Blac Sea Journal of Health Sci, 2021; 7(3):311-319

Address for correspondence/reprints:

Sema Baghaki

Telephone number: +90 (537) 733 08 99

E-mail: semabaghaki@hotmail.com

Introduction

Urinary incontinence (UI) is defined as involuntary leakage of urine by the International Continence Society (ICS) (1). It is known that approximately 50% of adult women have urinary incontinence, but only 25% to 61% of these consult a physician (2,3). Risk factors for UI include obesity, parity, type of delivery, advanced age, and family history (3-7). The major clinical types of UI include stress incontinence (SUI), incontinence with maneuvers with increased intraabdominal pressure; urge incontinence (UUI), incontinence together with feelings of urgency; and mix incontinence (MUI), which is a combination of stress and urge incontinence (8,9).

Methods such as the Q-type test, fluoroscopy, X-ray cystourethrography, and video-urethrocystography, which are used to evaluate the bladder neck and urethra mobility and are the necessary parameters for the diagnosis and treatment of UI, are difficult to apply, costly, and some require the use of ionizing radiation (10,11). In the last few decades, transperineal ultrasonography has been used for the diagnosis of UI, in the determination of the surgical method, and objective evaluations of postoperative success. The bladder neck, urethrovesical junction, and urethral hypermobility can be seen with transvaginal and transperineal ultrasonography (USG), which is a noninvasive and safe method (12-15).

The aim of the study was to present the importance of transperineal USG in the diagnosis of incontinence by evaluating the length of the urethra, bladder wall thickness, posterior urethrovesical angle (PUVA), and post-operative residual volume.

Methods

The study was conducted in our institution between December 2012 and May 2013 after obtaining Ethics Committee approval. Women age between 40 and 55 years were included in the study. The study group consisted of 45 patients who were diagnosed as having urinary incontinence clinically and urodynamically, and the control group comprised 25 healthy women who were clinically and urodynamically continent. Twenty patients with SUI, 13 with detrusor instability and UUI, and 12 patients with MUI were included in the incontinence group. The procedures to be performed were explained verbally and consent was obtained. Those who had major pelvic surgery, pelvic organ prolapses, diabetes mellitus and glucose intolerance, and high calcium levels were excluded from the study. Those with urinary infections were included in the study after receiving treatment.

Age, height, weight, number of births, type of delivery (vaginal birth, cesarean-section), history of birthweight over 4000 g, chronic diseases, menopausal status, and previous urogynecologic surgery were examined. Urine analysis, urine culture, serum calcium levels, and fasting and postprandial blood glucose levels were assessed before the study. In addition, gynecologic and neurologic examinations were performed, and pelvic organs were assessed using transvaginal USG.

In this study, an LOGIQ 200 PRO (Healthcare Korea/2008) ultrasound device and central 3.5 Mhz convex abdominal probe were used for transperineal USG. Urodynamic examinations were performed using a multichannel urodynamic device (Life-Tech, Inc., Texas/USA, 2009).

The patients were examined on a gynecology table with a 45-degree angle between the body axis and the legs in the supine position during rest and the Valsalva maneuver. The probe was placed sagittally to the perineum; when the symphysis pubis, urethra, bladder, vagina, and rectum could be seen clearly on the monitor, the image was frozen. In cases where these anatomical structures could not be clearly displayed at the same time, it was aimed to include only the symphysis pubis, urethra, and bladder in the image area (16).

Measurements were taken on the image for the calculation of the posterior urethrovesical angle (PUVA, ß angle), Dx, Dy distances, urethral length, bladder thickness, and residual volume. Gynecologic examinations and ultrasonographic measurements were performed by the same physician.

While the urethral length measurement was performed, the abdominal probe was placed in the perineum without pressure on the urethral meatus and the distance between the bladder neck and the external urethral meatus was measured in the bladder with residual urine.

In order to measure Dx and Dy distances, two parallel lines passing through the central and internal os of the pubis were used, and a third line (dotted line) that crossed these lines at an angle of 90 degrees and passed through the inferior corner of the symphysis pubis were used (Figure 2). The Dy distance was measured as the urethral length between two parallel lines. The Dx distance was measured as the distance between the internal os and the line passing through the pubis inferior (17,18).

When measuring PUVA(ß), the angle between a line passing through the urethral axis and a second line passing through the posterior of the bladder base was measured. The patient was asked to perform a Valsalva maneuver without disturbing the position. PUVA was measured by freezing the image at the time of maximum descent.

Urine volume measurement was performed within 10 min after micturition. Three patients with pathologic values residual urine volumes of more than 50 mL were excluded from the study to ensure standardization. To calculate the residual urine volume, post-micturition measurements were performed by imaging the bladder in transverse and sagittal planes with a probe placed a few centimeters below the pubis. The longest oblique diameter (H), transverse width (W), and sagittal anterior-posterior length (D1) were measured in each patient. The formula 0.65xHxWxD1 was used to calculate the bladder volume (19). While the bladder wall thickness was measured, the abdominal probe was placed vertically in the perineum and the anterior bladder wall thickness corresponding to the internal urethra meatus was measured.

Urethral length, bladder wall thickness and residual volume in supine position and at rest, and PUVA in the supine position and at rest and during the Valsalva maneuver are recorded to examine the variability between each group and the control group.

Statistical analysis

Statistical analysis was performed using the SPPS ver. 12.0 program. One-way analysis of variance (ANOVA) was used for normally distributed numerical parameters, and Tukey's honestly significant difference (HSD) test was used as a post-hoc test. The Kruskal-Wallis test was used for comparisons between three or more groups in non-normally distributed numerical parameters. Cross-table statistics were used to compare categorical variables (Chi-square). Statistical significance was identified as $p=0.05$

Results

Forty-five (64.28%) patients aged between 40 and 55 (mean age, 46.4±9.2) years, who were clinically and urodynamically diagnosed as having urinary incontinence and had no major pelvic surgery or pelvic organ prolapse, and 25 (35.72%) patients with a mean age of 45.4±6.9 years who were accepted as being urodynamically and clinically continent (control group) were included in our study. Twenty (28.6%) patients with stress urinary incontinence (SUI), 13 (18.6%) with detrusor instability (DI) and urge urinary incontinence (UUI), and 12 (17.1%) with mixed urinary incontinence (MUI) comprised the incontinence group. The demographic findings of the participants are presented in Table 1. No statistically significant difference was found between the groups in terms of age, body mass index (BMI), parity, type of delivery ($p> 0.05$).

The transperineal USG findings are presented in Table 2. When the measurements made with transperineal ultrasound were compared, no statistically significant difference was observed between the patients in the control group and the SUI, UUI, MUI groups in terms of urethral length, bladder wall thickness, and posterior residual urine volume measured in the supine position ($p>0.05$). There was no significant difference in terms of residual urine volume measured with the catheter during urodynamics between the continent and urinary incontinent groups ($p>0.05$). However, the residual urine volume measured using transperineal USG was 10.8% higher than the urine volume measured with urodynamics. There was no statistically significant difference between the patients with urinary incontinence and controls in terms of D-PUVA, which expressed the change of PUVA during rest and straining ($p>0.05$).

Statistical comparisons between the groups in terms of PUVA are presented in Table 3. PUVA was significantly higher at rest and in the Valsalva maneuver in the SUI and MUI groups than in the control group ($p<0.001$). However, no significant difference was found between the UUI group and the control group, or between the SUI and MUI groups during rest and the Valsalva maneuver ($p>0.05$).

There was a significant difference between the SUI and UUI groups during the Valsalva maneuver ($p<0.001$), and between the MUI and UUI groups during rest and the Valsalva maneuver ($p<0.006$, $p<0.001$).

Table 1. Demographic data

	SUI n=20 (28.6%)	UI n=13 (18.6%)	MUI n=12 (17.1%)	Control n=25 (35.7%)	p- value
Age (mean±SD)	47.1±7.7	45.4±12.9	46.9±7.3	45.4±6.9	[b]0.897
BMI (mean±SD)	32.2±5.2	29.8±4.8	30.5±6.6	29.0±5.6	[b]0285
Parity (mean±SD)	3.3±1.6	3.4±1.6	4.6±3.4	3.0±1.2	[c]0.777
Delivery Type					
Cesarean section (n,%)	2 (10%)	1 (7%)	2 (16%)	2 (8%)	[a]0.188
Vaginal (n,%)	18 (90%)	12 (93%)	10 (84%)	23 (92%)	[a]0.879
4000 g Over Birth	5 (25%)	3 (23%)	4 (33.3%)	6 (24%)	[a]0.124
Menopause	8 (40%)	5 (38%)	4 (33%)	7 (28%)	[c]0.702

a Chi-square and, b One-way-ANOVA, c Kruskal-Wallis tests were used for the statistical analysis.
* p<0.05, significantly different groups.
SUI: stress urinary incontinence; UUI: urge urinary incontinence; MUI: mixed urinary incontinence; BMI: body mass index

Table 2. Perineal ultrasonography data

		SUI n=20 (28.6%)	UUI n=13 (18.6%)	MUI n=12 (17.1%)	Control n=25 (35.7%)	p-value*
Length of Urethra (Mm)	Mean±Sd	32.5±1.8	33.1±3.2	33.5±2.0	32.7±2.8	[b] 0.697
	Median-(Min-Max)	32.8-(27.9-35.4)	34.2-(27.5-38.8)	33.6-(29.5-36.7)	31.7-(27.9-37.5)	
Bladder Thickness (Mm)	Mean±Sd	*2.04±0.33*	*2.28±0.44*	2.17±0.33	*2.1±0.4*	*[b] 0.325*
	Median-(Min-Max)	2.1-(1.5-2.8)	*2.2(1.7-3.3)*	2.1-(1.7-2.9)	*2-(1.5-2.9)*	
Prv (Usg)	Mean±Sd	*2.7±4.1*	*6.5±10*	*2.6±2.5*	*3.7±6.4*	*[b] 0.791*
	Median-(Min-Max)	*0.25-(0-13)*	1-(0-28)	2-(0-8)	1-(0_28)	
Prv (Catheter)	Mean±Sd	*3.2±4.7*	*3.4±4.3*	*5.2±9.4*	*2.6±4.3*	*[b] 0.795*
	Median-(Min-Max)	*1-(0-20)*	*0-(0-12)*	*1-(0-33)*	*0-(0-15)*	
Puva (Rest)	Mean±Sd	*115.3±12.9*	*107.5±12*	*122±9*	*103.8±8.3*	*[a] 0.001*
	Median-(Min-Max)	*116-(95-139)*	*110-(92-133)*	*122.5-(107-141)*	*105-(92-118)*	
Puva (Valsalva)	Mean±Sd	*143.9±10.1*	*128.2±8.9*	*148.4±7.4*	*127.6±9.2*	*[b] <0.001*
	Median-(Min-Max)	*144.5-(121-160)*	*125-(117-145)*	*148-(138-163)*	*125-(110-155)*	
D-Puva	Mean±Sd	*28±10*	*20.7±7.1*	*26.4±5.3*	*24±7.3*	*[c] 0.096*
	Median-(Min-Max)	*27-(12-46)*	*20-(11-33)*	*26-(18-39)*	*23-(13-47)*	

a chi-square, b one-way-ANOVA and c Kruskal-Wallis tests were used for the statistical analysis.
* p<0.05 means significantly different groups
SUI: stress urinary incontinence; UUI: urge urinary incontinence; MUI: mixed urinary incontinence; BMI: body mass index PRV: Post-void residual volume PUVA: posterior urethrovesical angle

Table 3. Statistical comparisons between groups for PUVA

	Test	P (rest)	P (Valsalva)
SUI and Control	Tukey HSD	[b] **0.004**	[b] **<0.001**
UUI and Control	Tukey HSD	[b] 0.739	[b] 0.998
MUI and Control	Tukey HSD	[b] **<0.001**	[b] **<0.001**
SUI and UUI	Tukey HSD	[b] 0.185	[b] **<0.001**
SUI and MUI	Tukey HSD	[b] 0.311	[b] 0.534
UUI and MUI	Tukey HSD	[b] **0.006**	[b] **<0.001**

[b]One-way ANOVA p<0.001

Discussion

The main result of our study was that PUVA measured using perineal USG was significantly higher in the SUI and MUI groups during rest and the Valsalva maneuver compared with the UUI and control group. However, the D-PUVA value, which indicates the change of PUVA with the Valsalva maneuver, showed no significant difference in our study and control groups.

Perineal ultrasonographic imaging has an important role among the radiodiagnostic methods in a wide area, ranging from the simple cotton swab test to magnetic resonance imaging (MRI) for the evaluation of the lower urinary tract system and the diagnosis of stress urinary incontinence. The advantages of USG are that it is easy to use, reliable, real-time, with no X-ray risk, no contrast agent, and it can be performed in office conditions. It takes a place among other radiologic diagnostic methods for the assessment of the pelvic floor (10-15). Numerous studies and classifications have been made to detect the etiology of urinary incontinence to date. First, Green et al. attributed the cause of stress incontinence to PUVA changes based on clinical experience, defined PUVA as the angle between the urethral axis and the axis of the bladder base, and expressed that PUVA might be important for the selection of the appropriate surgical method in patients with SUI in 1962 (20). Koelbl et al. (21) measured PUVA and the urethral angle (alpha angle) using perineal USG and cystourethrography and found a correlation between the two methods, showing that non-invasive perineal USG was superior to cystourethrography in terms of ease of use and adverse effects. It has also been suggested that perineal USG was more reliable than transvaginal USG (22).

Similar to our study results, PUVA was found to be different in patients with SUI during rest and the Valsalva maneuver when compared with continent women, and it was suggested that perineal USG and PUVA measurements could be used for the diagnosis of patients with SUI (23,24). It has also been suggested that preoperative evaluation of SUI using PUVA measurements with perineal USG might be useful in cases of surgical failure or complications and physicians interested in urogynecology should use this method more frequently (22). We think that perineal USG, which still only has limited use in our country, should be used routinely in the evaluation incontinent women.

In our study, the PUVA value of the patients with SUI and MUI during the Valsalva maneuver was statistically different and greater than those with UUI and normal continence. In conclusion, although PUVA measurements with transperineal USG did not determine the type of incontinence, we found that it could detect patients with anatomic defects (23-25).

In a study in which Yalçın et al. investigated the role of PUVA in determining the type of urinary incontinence, PUVA values were measured during rest and straining using transperineal USG, and D-PUVA values were significantly higher during straining than at rest ($p<0.01$). When compared with SUI and MUI, there was no statistically significant difference between PUVA values while straining and at rest in patients who had DI ($p>0.05$). With these results, it was thought that the PUVA values during rest and with straining or the change of angle during straining in patients with urinary incontinence were not effective parameters in the differential diagnosis of incontinence types (26).

In our study, the mean urethra length was 32.8 ± 2.5 cm. There was no significant difference between the groups and it was found to be shorter than the reported average in the literature. De Souza et al., who measured the length of urethra using MRI and determined the mean value as 3.1 cm, found this difference to be associated with a slight forward twist of the urethra in the supine position and with the flattening and elongation of the urethra in surgical and cadaveric measurements. Contrary to the normal anatomic position, examinations in the supine position do not allow the evaluation of the dynamic changes in the urethra, retropubic cavity, and vesicourethral angle with changes in intra-abdominal pressure as in the natural position and it measures shorter its actual length (27).

In our study, bladder wall thickness measured using USG in patients with SUI, UUI, MUI, and continent women, was measured as 2.04, 2.28, 2.17, and 2.10 mm, respectively. Although the bladder wall thickness was greater in the group with UUI than the other groups, no statistical difference was found between them. However, unlike our data, in many studies bladders wall thickness was measured thicker in transvaginal USG measurements in patients with a diagnosis of overactive bladder (28,29). This difference may be related to the bladder wall thickness depending on age and urine volume in the bladder or may be related to the transperineal USG method we used (30).

Measurement of residual urine volume helps in the detection of post-micturition residual urine and distinguishing urinary retention and overflow incontinence. Although the residual urine volume can be determined using USG, this method has a standard error of 15-20%. Similar to our study results, there are studies that found the difference between the mean residual urine volume measured using a urethral catheter and the volume of urine estimated using pelvic USG formulae (31,32). On the other hand, an approximate measurement of bladder urine volume can be performed using real-time USG, but the measurement obtained in cases where changes in residual urine need to be measured more accurately may not be sufficiently reliable (33). In terms of the residual urine volume in our study, no statistically significant difference was found between the study and control groups in terms of the values calculated using transperineal USG and vesical catheter during urodynamics. A 10.8% standard error was found for the value we detected using transperineal USG. This value is close to the standard error in the literature and lower than that value. Although residual urine measurement with a catheter is the gold standard, using transperineal ultrasound is an easy, non-invasive, and may be an alternative method for urethral catheterization (32).

The main limitation of our study was the difficulty in standardizing the maximum straining of patients during the Valsalva maneuver when PUVA was measured. Although the patients were warned about maximum straining before the examination, subjects who did not strain at the desired level made the evaluation difficult. In this case, the image with maximum straining was taken into consideration.

Conclusion

Transperineal USG is a simple and non-invasive method that provides detailed visualization of the bladder, urethra, and pelvic support structures in patients with urinary incontinence. It could demonstrate structural changes in the pelvic floor structure with examinations at rest and during the Valsalva maneuver. The measurement of PUVA using transperineal USG could not determine the type of incontinence but it could detect patients with anatomic defects. Measurement of bladder wall thickness can be performed to help in diagnosis in patients with suspected detrusor instability. Transperineal USG could be an easy and reliable alternative method for residual urine volume measurements in cases where catheterization cannot be performed.

Main Points

•The main result of our study was that posterior urethrovesical angle (PUVA) measured using perineal USG was significantly higher in the SUI and MUI groups during rest and the Valsalva maneuver compared with the UUI and control group.

•Transperineal USG and PUVA measurements can be used for the diagnosis of patients with SUI and MUI.

•Although residual urine measurement with a catheter is the gold standard, using transperineal ultrasound is an easy and non-invasive method to support the diagnosis of SUI or MUI and it can be an alternative method to urethral catheterization.

Ethics Committee Approval: This study was performed on the extracted human teeth. Clinical Studies Ethics Committee of Ordu University, Faculty of Medicine was not needed.

Peer-review: Externally peer-reviewed.

Author Contributions:
Concept: N.Ç, C.A , *Design:* N.Ç, C.A, *Literature search:* N.Ç, K.D, S.B, *Data Collection and Processing:* N.Ç, K.D, *Analysis or Interpretation:* N.Ç, K.D, *: Writing:* N.Ç, C.A, K.D, S. B.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study hasn’t received no financial support.

References

1. Abrams P, Cardozo L, Fall M, et al. The standardization of terminology in lower urinary tract function: report from the standardization subcommittee of the International Continence Society. Urol J 2003;61:37–49.
2. Morrill M, Lukacz ES, Lawrence JM, et al. Seeking healthcare for pelvic floor disorders: a population-based study. Am J Obstet Gynecol 2007;197:86.e1.
3. Hannestad YS, Rortveit G, Hunskaar S. Help-seeking and associated factors in female urinary incontinence. The Norwegian EPINCONT Study. Epidemiology of Incontinence in the County of Nord-Trøndelag. Scand J Prim Health Care 2002; 20:102.
4. Subak LL, Richter HE, Hunskaar S. Obesity and urinary incontinence: epidemiology and clinical research update. J Urol 2009; 182:S2.
5. Rortveit G, Hannestad YS, Daltveit AK, Hunskaar S. Age- and type-dependent effects of parity on urinary incontinence: the Norwegian EPINCONT study. Obstet Gynecol 2001; 98:1004.
6. Lukacz ES, Lawrence JM, Contreras R, Nager CW, Luber KM. Parity, mode of delivery, and pelvic floor disorders. Obstet Gynecol 2006; 107:1253.
7. Lawrence JM, Lukacz ES, Liu IL, Nager CW, Luber KM. Pelvic floor disorders, diabetes, and obesity in women: findings from the Kaiser Permanente Continence Associated Risk Epidemiology Study. Diabetes Care 2007; 30:2536.

8. Abrams P, Cardozo L, Fall M, et al. The standardization of terminology of lower urinary tract function: report from the standardization sub-committee of the International Continence Society. Neurourol Urodyn 2002;21:167–78.
9. Wood LN, Anger JT. Urinary incontinence in women. BMJ 2014;349: g4531
10. Karram MM, Bhatia M. The Q-tip test: standardization of the technique and its interpretation in women with urinary incontinence. Obstet Gynecol 1988;71(6 Pt 1):807– 811.
11. Mc Guire EJ, Lytton B, Pepe V, Kohorn EI. Stress urinary incontinence. Obstet Gynecol 1976;47(3):255–264.
12. Koelbl H, Strassegger H, Riss PA, Gruber H. Morphologic and functional aspects of pelvic floor muscles in patients with pelvic relaxation and genuine stress incontinence. Obstet Gynecol 1989;74(5):789– 795.
13. Benson JT, Sumners JE, Pittman JS. Definition of normal female pelvic floor anatomy using ultrasonographic techniques. J Clin Ultrasound 1991;19(5):275– 282.
14. Johnson JD, Lamensdorf H, Hollander IN, Thurman AE. Use of transvaginal endosonography in the evaluation of women with stress urinary incontinence. J Urol 1992;147(2):421–425.
15. Kohorn EI, Scioscia AL, Jeanty P, Hobbins JC. Ultrasound cystourethrography by perineal scanning for the assessment of female stress urinary incontinence. Obstet Gynecol 1986;68(2):269–272.
16. Dietz HP, Clarke B. Translabial color Doppler urodynamics. Int Urogynecol J Pelvic Floor Dysfunct 2001;12(5):304-7.
17. Buthon G. Pad weighing test. in; urogynecology. Cordozo L (ed.) Churchill Lvingstone, New York, 199; s: 135-140.
18. Artibani E, Andersen JT, Gajewski JB, Ostegard DR, Raz S, Tubaro A. Imaging and other investigations. In:Abrams P, Cardozol L, Khoury S, Wein A, editors. Incontinence. Plymouth (UK):Plymbridge Distributors Ltd; 2002:425-477
19. Hartnell GG, Kiely EA, Williams G. Real-time ultrasound measurement of bladder volume: A comparative study of three methods. Br. J. Radiol. J. Urol. 1983; 130; 249- 51.
20. Green JH. Develoment of a plan for the diagnosis and treatment of urinary stress incontinence. Am J Obstet Gynecol. 1962;83;632-648.
21. Koelbl H, Bernaschek G, Wolf G. A comparative study of perineal ultrasound scanning and urethrocystography in patients with genuine stress incontinence. Arch Gynecol Obstet. 1988:244:39-45.
22. Alper T, Çetinkaya M, Okutgen S, Kökçü A, Malatyalıoğlu E. Evaluation of urethrovesical angle by ultrasound in women with and without urinary stress incontinence. Int Urogynecol J 2001; 12:308-311.
23. Sendag F, Vidinli H, Kazandi M, et al. Role of perineal sonography in the evaluation of patients with stress urinary incontinence. Aust NZJ Obstet Gynaecol. 2003;43(1):54-7.
24. Pizzoferrato AC, Fauconnier A, Bader G. Value of ultrasonographic measurement of bladder neck mobility in the management of female stress urinary incontinence. Gynecol Obstet Fertil. 2011 Jan;39(1):42-8.
25. Hu Y, Lou Y, Liao L, et al. Comparison of urodynamics and perineal ultrasonography for the diagnosis of mixed urinary incontinence in women. J Ultrasound Med. 2018 Nov;37(11):2647-2656.
26. Yalçin ÖT, Şener T, Hassa H, Özalp S, Yıldırım A. The efficacy of the posterior urethro-vesical angle measurement for diagnosing the type of urinary incontinence. Turkiye Klinikleri J. Gynecol Obst 1996;6(4):316-20.
27. De Souza NM, Daniels OJ, Williams AD, Gilderdale DJ, Abel PD. Female urinary genuine stres incontinence: Anatomic considerations at MR imaging of the paravaginal fascia and urethra-initial observations. Radiology 2002;225:433-439
28. Oelke M, Khullar V, Wijkstra H. Review on ultrasound measurement of bladder or detrusor wall thickness in women: techniques, diagnostic utility, and use in clinical trials. World J Urol. 2013 ;31(5):1093-104.
29. Abou-Gamrah A, Fawzy M, Sammour H, Tadros S. Ultrasound assessment of bladder wall thickness as a screening test for detrusor instability. Arch Gynecol Obstet. 2014;289(5):1023-8.

30. Panayi DC, Khullar V, Fernando R, Tekkis P. Transvaginal ultrasound measurement of bladder wall thickness: a more reliable approach than transperineal and transabdominal approaches. BJU Int. 2010 ;106(10):1519-22.
31. Yeniyol CÖ, Çiçek S, Çiçek E, Zeyrek N, Arslan M, Ayder AR. Abdominal ultrasound versus urethral catheterisation in the measurement of residual urine volume. Turkish Journal of Urology; 27(1): 56-58, 2001.
32. Dinçel Ç, Akbulut H, Islim F et al. Residual urine measurements: Comparison between transabdominal ultrasonography and urethral catheterisation. Turkish Journal of Urology; 25(3): 314-318,1999
33. Kiely EA, Hartnell GG, Gibson RN, Williams G. Measurement of bladder volume by real-time ultrasound. Br J Urol. 1987;60(1):33-5.