

Received: 2019.04.20

Accepted: 2019.07.11

Published: 2019.10.28

Three-Dimensional Transperineal Ultrasonography for Diagnosis of Female Occult Stress Urinary Incontinence

Authors' Contribution:

Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

BCF 1 **Yitong Yin**
ADG 1 **Zhijun Xia**
AF 2 **Xiaoyu Feng**
BD 1 **Meng Luan**
CE 1 **Meiying Qin**

1 Department of Obstetrics and Gynecology, Pelvic Floor Disease Diagnosis and Treatment Center, China Medical University Affiliated Shengjing Hospital, Shenyang, Liaoning, P.R. China

2 Department of Ultrasound, China Medical University Affiliated Shengjing Hospital, Shenyang, Liaoning, P.R. China

Corresponding Author: Zhijun Xia, e-mail: xiazj@sj-hospital.org

Source of support: The National Ministry of Science and Technology of China provided financial support for this research. Project number: 2014BAI05B02

Background: We evaluated the utility of three-dimensional transperineal ultrasonography in detecting occult stress urinary incontinence in women undergoing anterior pelvic floor reconstruction surgery for severe cystocele.

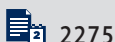
Material/Methods: We enrolled 207 women with stage III-IV cystocele without urinary stress incontinence. One week before the operation, the patients underwent pelvic floor ultrasonography. We measured the vertical distance between the bladder neck and posterior margin of the pubic symphysis, the posterior vesicourethral angle, the urethral rotation angle, the formation of funnel shape, the hiatus area, and the length of the urethra and the funnel shape. Postoperatively, the patients were evaluated for symptoms of stress urinary incontinence and with the 20-minute pad test.

Results: The posterior vesicourethral angle with Valsalva maneuver, the difference in the posterior vesicourethral angle between the resting state and with the Valsalva state, and the angle of the proximal urethra were larger in the incontinence-positive group than in the incontinence-negative group ($P < 0.05$). Funnel shape urethra was longer in the incontinence-positive group than in the incontinence-negative group ($P < 0.05$). The cutoff value was 137.5° for the posterior vesicourethral angle with Valsalva maneuver, 39.5° for the difference in the posterior vesicourethral angle, 44.5° for the angle of the proximal urethra, and 0.35 cm for the length of the funnel shape. Multivariate analysis revealed that the difference between the posterior vesicourethral angle in the resting state and with Valsalva, the angle of the proximal urethra, and the length of funnel shape were strongly correlated with occult stress urinary incontinence.

Conclusions: Ultrasonography is an effective method for identifying occult stress urinary incontinence.

MeSH Keywords: **Diagnosis • Ultrasonography • Urinary Incontinence**

Full-text PDF: <https://www.medscimonit.com/abstract/index/idArt/917086>



2275



3



2



22



Background

Pelvic organ prolapse and urinary incontinence are common in older women. Jonsson et al. [1] reported that 11% of women over the age of 80 years required surgery for these conditions. Because of the similar pathogenesis, about 40% of patients have both pelvic organ prolapse and urinary incontinence at the time of diagnosis [2]. However, because of the relative position of the urethra and bladder, patients with severe bladder prolapse often do not have leakage of urine when coughing, laughing, sneezing, or jumping before surgery, but the symptoms appear after surgery [3]. Thus, these patients do not have urinary incontinence preoperatively, as defined by the International Continence Society, but they do have occult stress urinary incontinence (OSUI) [4,5].

To prevent postoperative urinary incontinence, accurate assessment of incontinence preoperatively is important. History-based and urodynamics-based prediction tools and the urinary pad test are commonly used methods for identifying OSUI [3,6,7], but they all have deficiencies. History-based prediction tools are subjective. Urodynamic measurements can have artifacts caused by gauze inserted into the vagina to push back the prolapsed bladder, causing distorted bladder perfusion. The urinary pad test also is not suitable because of the lack of incontinence symptoms before surgery. Chughtai et al. [8] reported that even with the use of a prolapse reduction device, 6–69% of OSUI cases remained undiagnosed.

Ultrasonography has been widely used in pelvic floor examination because it is noninvasive, convenient, and relatively low cost. Moreover, ultrasonography can reveal positions of pelvic structures during dynamic events [9–11]. However, the diagnostic value of ultrasonography for OSUI has not been studied, and ultrasonographic indicators have not been established in patients with OSUI. The purpose of this study was to determine the value of ultrasonography in making the diagnosis of OSUI preoperatively in patients with severe cystocele and in the evaluation of new-onset urinary incontinence after surgery.

Material and Methods

Patients

This was a prospective study of 230 patients with cystocele who underwent anterior pelvic floor reconstruction [12] with an Avaulta Solo™ polypropylene mesh repair system. Cystoceles of all patients were III–IV stage according to the Pelvic Organ Prolapse Quantification system. The front wing of the mesh was fixed to the arcus tendineus fascia pelvis 1 cm to the pubic symphysis, and the posterior wing was fixed to the arcus tendineus fascia pelvis 1 cm to the sciatic spine. Patients who

had preoperative symptoms of urinary incontinence, including stress incontinence, were excluded. Other exclusion criteria were overactive bladder, urogenital fistula, and urethritis, in which the pad test is not suitable. Patients were assigned to 1 of 2 groups according to whether they developed symptoms of urinary incontinence during the 3-month follow-up after surgery (OSUI (+)) or did not have incontinence (OSUI (–)). Informed consent was obtained from all study participants, and the study was approved by the Ethics Committee of China Medical University affiliated Shengjing Hospital.

Stress incontinence testing

The diagnostic criteria of stress urinary incontinence included subjective criteria and objective criteria. The subjective criteria were symptoms of urine leakage with coughing, sneezing, walking, running, or changing position of the body [13]. The objective criterion was the results of the 20-minute pad test. During the 20 minutes, patients were asked to complete these actions: cough 10 times, do 10 knee bends, jump up and down 10 times, bear down 10 times, walk upstairs and downstairs 10 times, and walk quickly for 10 minutes. The weight of the pad before and after these actions was measured. The test was considered positive if the weight increased by more than 1 g [14]. We considered that patients had new stress urinary incontinence if either subjective or objective criteria were satisfied.

Ultrasonography

The patients underwent pelvic floor ultrasonography 1 week before the operation. The examination was performed by the same experienced physician. The GE Healthcare Voluson E8 ultrasonic diagnostic system equipped with RAB6-D transperineal probes was used.

For the ultrasonographic examination, patients lay on the bed in the lithotomy position with no more than 200 mL urine in the bladder. The prolapse was reduced by the ultrasound physician. Sagittal and coronal examinations of the pelvic organs were performed with the probe in the perineum. The vertical distance between the bladder neck and posterior margin of the pubic symphysis (BSD) and the posterior vesicourethral angle (β angle) were measured during rest and with the Valsalva maneuver (Figure 1). The variation of BSD and β angle also were calculated. The rotation angle of the proximal urethra (α angle), hiatus area, length of the urethra, formation of the urethra funnel shape (Figure 2), and the length of the funnel shape also were measured.

Statistical analyses

Statistical Product and Service Solutions (SPSS) 19.0 software (IBM, Armonk, NY, USA) was used in statistical analyses. Comparison of

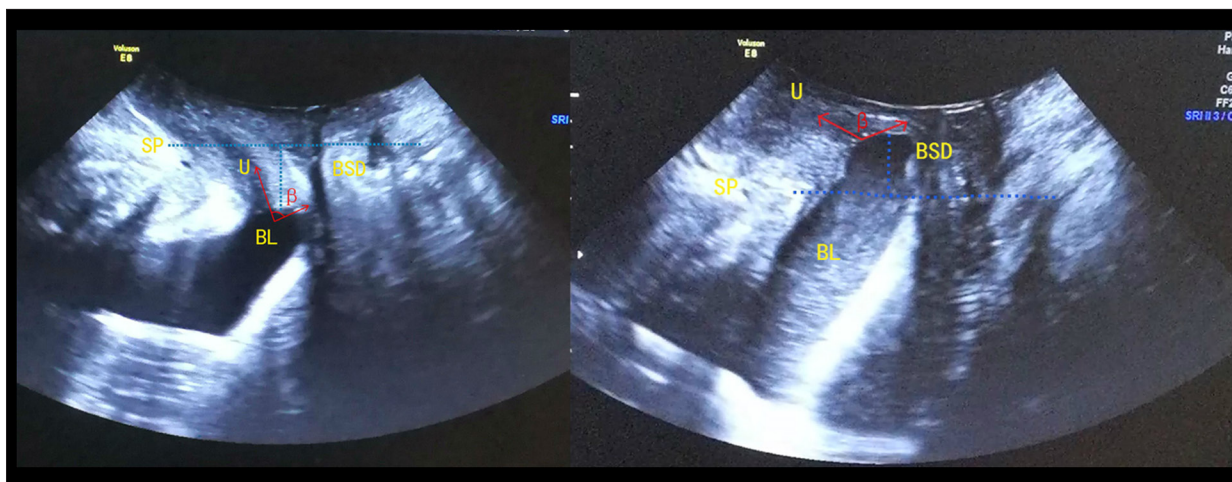


Figure 1. BL – bladder; U – urethra; SP – symphysis pubis; BSD – vertical distance between bladder neck and posterior margin of pubic symphysis β angle: posterior vesicourethral angle

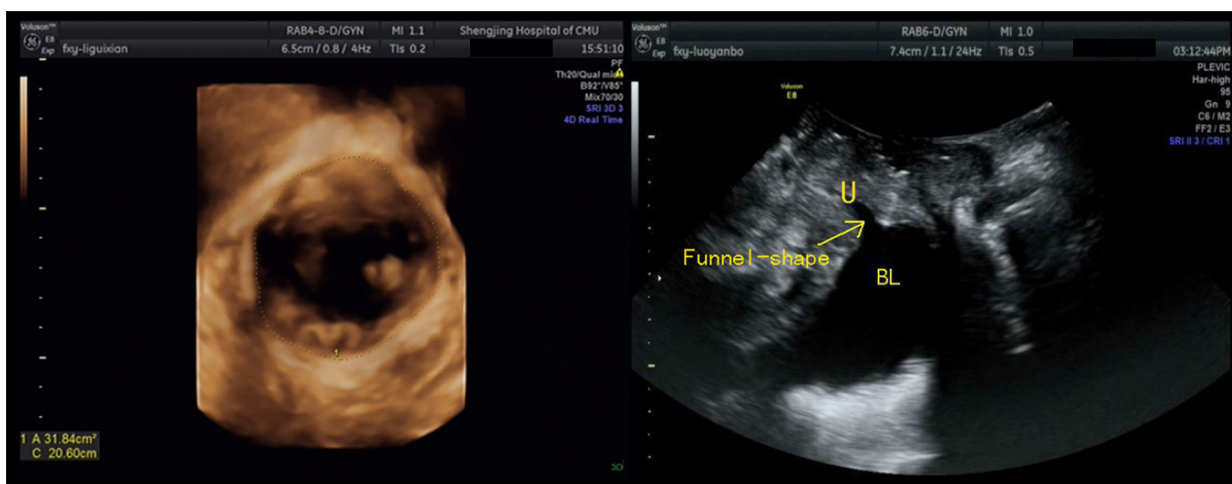


Figure 2. Left picture shows the hiatus area. B in right picture – bladder; U – urethra; Arrow – funnel shape.

means between groups was performed with the Mann-Whitney U test for skewed distributed variables. A receiver operator characteristic (ROC) curve was used to determine the relationship between the OSUI and ultrasound indicators. The chi-square test was used for comparison of proportions. Logistic regression was used to determine the contributions of the indicators to the diagnosis of OSUI. $P < 0.05$ was defined as statistically significant.

Results

Two hundred and seven of the 230 patients completed the scheduled follow-up during the 3 months after surgery; 23 were lost to follow-up. Seventy patients were placed in the OSUI (+) group; 58 of them had a subjective SUI report, 31 had a positive pad test, and 19 had both a subjective SUI report and positive pad test. One hundred thirty-seven patients were in the OSUI (-) group.

Demographic characteristics of the patients are listed in Table 1. There were no statistically significant differences between the 2 groups in any of the characteristics recorded.

Results of the ultrasonic examinations of the 2 groups are presented in Table 2. Values for the β angle during Valsalva maneuver, variation in the β angle, and the α angle were significantly higher in the OSUI (+) patients than in the OSUI (-) patients ($P < 0.05$). The probability of the formation of a funnel shape was not significantly different in the 2 groups ($P = 0.117$), but the funnel shape was longer in the OSUI (+) group ($P < 0.007$). The remaining indicators were not significantly different between the 2 groups.

We conducted ROC analysis to identify the predictive value of the above indicators. The area under the curve (AUC) of the variation of β angle was 0.629, and the cutoff was 39.5 (sensitivity 0.571, specificity 0.684, $P = 0.003$, 95% CI 0.547–0.712). The AUC of the

Table 1. Patients' demographic characteristics.

	OSUI (+)	OSUI (-)	P
Age (median, 25–75 IQR)	69 (62–77)	70 (64–77)	0.337 ^a
Parity (median, 25–75 IQR)	2 (1–3)	2 (1–3)	0.327 ^a
BMI (median, 25–75 IQR)	25.80 (23.82–27.75)	25.80 (24.50–27.10)	0.696 ^a
Previous hysterectomy (n/N, %)	11/70 (15.7%)	13/137 (9.4%)	0.186 ^b
Previous cystocele repair (n/N, %)	9/70 (12.8%)	8/137 (5.8%)	0.082 ^b
Mode of delivery			0.348 ^a
Vaginal (n/N, %)	44/70 (62.9%)	95/137 (69.3%)	
Forceps (n/N, %)	9/70 (12.9%)	15/137 (10.9%)	
Cesarean (n/N, %)	17/70 (24.3%)	27/137 (19.7%)	
Degree of cystocele			0.460 ^b
III (n/N, %)	57/70 (81.4%)	117/137 (85.4%)	
IV (n/N, %)	13/70 (18.5%)	20/137 (14.6%)	

^a Mann-Whitney test; ^b chi-square test. OSUI – occult stress urinary incontinence; BMI – body mass index; IQR – interquartile range.

Table 2. Results of sonographic examinations.

	OSUI (+)	OSUI (-)	P
BSD at rest	-12.4±6.71	-14.31±5.48	0.087 ^a
BSD with Valsalva	13.61±8.55	12.57±9.93	0.052 ^a
BSD difference ^c	25.14±11.99	26.00±10.64	0.725 ^a
β angle at rest	98.47±8.89	98.96±8.38	0.739 ^a
β angle with Valsalva	136.87±13.42	132.57±13.56	0.005a*
β angle difference ^c	38.40±14.26	33.60±14.35	0.002a*
α angle	42.11±12.46	39.79±8.27	0.003a* ^a
Length of urethra	3.17±0.40	3.29±0.36	0.063 ^a
Formation of urethra funnel-shape	28/70 (40%)	40/137 (29.2%)	0.117 ^b
Length of urethra funnel-shape	0.24±0.33	0.13±0.29	0.007* ^a
Area of hiatus	23.40±2.91	22.89±3.19	0.076 ^a

Values are presented as mean ± standard deviation. ^a Mann-Whitney test; ^b chi-square test; ^c difference between BSD and β angle at rest and with Valsalva. * $P < 0.05$. BSD – vertical distance between the bladder neck and posterior margin of the pubic symphysis. β angle, posterior vesicourethral angle. α angle, the rotation angle of the proximal urethra.

posterior urethral angle with Valsalva maneuver was 0.619, and the cutoff was 137.5 (sensitivity 0.750, specificity 0.657, $P = 0.005$, 95% CI 0.536–0.703). The AUC of the α angle was 0.626, and the cutoff was 44.5 (sensitivity 0.690, specificity 0.752, $P = 0.003$, 95% CI 0.536–0.715). The AUC of the length of funnel shape was 0.593, and the cutoff was 0.35 (sensitivity 0.643, specificity 0.838, $P = 0.029$, 95% CI 0.509–0.677). When these 4 indicators were combined for ROC analysis, the AUC was 0.714 (sensitivity 0.814, specificity 0.647, $P < 0.001$, 95% CI 0.549–0.754).

Based on the cutoff value of the variation of the β angle, patients were re-assigned into a variation of the β angle >39.5 group and a variation of the β angle <39.5 group. The probability of new urinary incontinence occurring in the >39.5 group was 57.1% (40/70), and in the <39.5 group it was 31.3% (43/137) ($P < 0.001$, OR 2.941, CI 1.636–5.288). We next analyzed the probability of new urinary incontinence occurring by univariate and multivariate analysis, defined by the cutoff value (Table 3). By univariate analysis, the β angle with Valsalva

Table 3. Univariate analysis and multivariate analysis for comparison of new urinary incontinence probability in reassigned groups defined by the cut-off value.

	Univariate analysis					Multivariate analysis			
	OSUI (+)	OSUI (-)	OR	95% CI	P	β	OR	95% CI	P
β angle difference ^a	40	43	2.953	1.628–5.357	<0.001*	0.928	2.530	1.173–5.460	0.018*
β angle with Valsalva	42	49	2.694	1.490–4.870	0.001*	0.293	1.340	0.624–2.878	0.453
α angle	43	48	2.915	1.607–5.286	<0.001*	1.085	2.959	1.567–5.587	0.001*
Length of funnel-shape	25	22	2.878	1.475–5.619	0.002*	0.993	2.699	1.304–5.589	0.007*

^a Difference in the posterior vesicourethral angle between the resting state and the Valsalva state OSUI, occult stress urinary incontinence. * $P < 0.05$.

maneuver, the α angle, and the length of funnel shape were all significantly more in the >39.5 group than in the <39.5 group by CI and p values. By multivariate analysis, variation of the β angle, the α angle, and the length of the funnel shape were significantly different in the 2 populations.

Discussion

In this study, we investigated whether pelvic ultrasonography could reliably diagnose OSUI in patients with severe cystoceles. A reliable test or tests to predict the occurrence of stress urinary incontinence that develops after surgery for correction of cystocele, where none was present preoperatively, has been needed. To clarify the role in diagnosis of OSUI, we evaluated the indicators of preoperative ultrasonography individually. We found that the values for the β angle during Valsalva maneuver, variation of the β angle, the α angle, and the probability of forming the funnel shape and the length of the funnel shape were higher in patients who developed OSUI than in those who did not. The ROC analysis showed that the diagnostic value of a combined index was higher than that of a single index. Through logistic multivariate analysis for an independent risk factor for OSUI, variation of β angle greater than 39.5 degrees, the α angle greater than 44.5, and length of the funnel shape longer than 0.35 cm were identified factors.

Based on the ultrasonographic findings, we concluded that increased urethral activity due to loosening or injury of the ligaments around the urethra is a major cause of OSUI. This supports the view of Delancey and coworkers [15,16]. Al-Saadi et al. [17] concluded that the urethral rotation angle and posterior urethral angle were significantly increased in patients with stress urinary incontinence, which was consistent with our findings. This agreement may be support for OSUI having the same mechanism as stress urinary incontinence, i.e., weakness and injury of muscles and fascial tissues surrounding the urethra [3]. Sendag et al. [18] found that patients with stress urinary incontinence had increased BSD,

whereas we found no relationship between BSD and incontinence. However, the patients in our study may be more complicated because they had severe cystocele. Pelvic floor injuries, especially with collapse of the hammock structure, also lead to increased bladder activity in patients with non-urinary incontinence, as reported by Lovegrove et al. [19]. The data in Table 2 also indicate that the funnel shape is easily formed in OSUI patients, and the length of the funnel shape is longer. This result is in accordance with the study by Brandt et al. [20], which suggests that funnel shape formation is common in stress urinary incontinence. This observation suggests that the urethral sphincter complex also is important in maintaining urinary continence.

To calculate the cutoff value, we performed ROC analysis for the positive sonography of patients with and without OSUI. Al-Saadi et al. [17] showed that when the urethral rotation angle is larger than 58.5°, or when the posterior urethral angle measured during Valsalva maneuver is larger than 141.5°, stress urinary incontinence was likely to occur. In our study, the cutoff value of urethral rotation angle and posterior urethral angle was smaller than that in the study for common stress urinary incontinence. However, unlike patients in the previous study, all patients in our study had incontinence complicated by severe cystocele. The main reason for differences in study results may be that the pelvic floor structure has more serious defects in cystocele, resulting in smaller urethral rotation angle and posterior urethral angle, which can cause urinary incontinence. Differences in race may also contribute to differences in the results. Our cutoff for funnel shape length was 0.35 cm, which means that the longer the funnel shape, the greater the probability of stress urinary incontinence. These results indicate that shorter urethral sphincter complex is correlated with urinary incontinence. Our results are consistent with those of Schroder et al. [21].

By regrouping the patients by cutoff of each index, we found the formation of funnel shape is not an independent risk factor for urinary incontinence. This finding suggests that urethral

funnels also may be important in patients with normal urinary control, but the longer the urethral funnel, the more likely OSUI is to occur because the urethral complex may be damaged. This opinion is consistent with the results of Macura et al. [22], who used magnetic resonance imaging to study the urethral complex. In logistic multivariate regression analysis, we found that that a posterior vesicourethral angle greater than 39.5°, rotation angle of the proximal urethra greater than 44.5°, and funnel shape longer than 0.35 cm were independent risk factors for OSUI. These results suggest that the main causes of OSUI are increased urethral mobility and shortened urethral sphincter complex.

In the past, the occurrence of urinary incontinence after cystocele repair could not be predicted reliably preoperatively. We believe that our study is the first to use pelvic floor ultrasonography to objectively identify patients with severe cystocele who are at risk for postoperative stress urinary incontinence, and the first to use ultrasonographic diagnostic criteria for identifying OSUI. Thus, screening cystocele repair candidates with pelvic sonography may be valuable in selecting patients for surgical repair. The most advantageous feature of ultrasonography is its ability to record dynamic movement of the soft-tissue structures of the pelvic floor. Other favorable

features are its relatively low cost, its non-invasiveness, and objectivity of the results.

This study has limitations. First, it was a single-center study of a modest number of Chinese women, so our results may not be applicable to other populations. The validity of our results should be assessed in a larger and more racially diverse sample of patients in multiple centers. Second, the study had only a 3-month follow-up of patients; longer-term follow-up should be a requirement of future studies.

Conclusions

The findings of this study indicate that transperineal ultrasonography is a promising objective method for preoperative screening of women with large cystoceles for occult stress urinary incontinence. The cause of the postoperative incontinence is mainly high activity of the urethra and shortening of the urethra sphincter complex.

Conflict of interest

None.

References:

1. Jonsson FM, Edenfield AL, Pate V et al: Trends in use of surgical mesh for pelvic organ prolapse. *Am J Obstet Gynecol*, 2013; 208: 71–79
2. Cartwright R, Kirby AC, Tikkinen KA et al: Systematic review and meta-analysis of genetic association studies of urinary symptoms and prolapse in women. *Am J Obstet Gynecol*, 2015; 212: 191–99
3. de Vries AM, Heesakkers J: Contemporary diagnostics and treatment options for female stress urinary incontinence. *Asian J Urol*, 2018; 5: 141–48
4. Jundt K, Wagner S, von Bodungen V et al: Occult incontinence in women with pelvic organ prolapse – Does it matter? *Eur J Med Res*, 2010; 15: 112–16
5. Weber AM, Abrams P, Brubaker L et al: The standardization of terminology for researchers in female pelvic floor disorders. *Int Urogynecol J Pelvic Floor Dysfunct*, 2001; 12: 178–86
6. Yande SD, Joglekar OV, Joshi M: Role of urodynamics in stress urinary incontinence: A critical appraisal. *J Midlife Health*, 2016; 7: 119–25
7. Jelovsek JE, Chagin K, Brubaker L et al: A model for predicting the risk of *de novo* stress urinary incontinence in women undergoing pelvic organ prolapse surgery. *Obstet Gynecol*, 2014; 123: 279–87
8. Chughtai B, Spettel S, Kurman J, De E: Ambulatory pessary trial unmasks occult stress urinary incontinence. *Obstet Gynecol Int*, 2012; 2012: 392027
9. Rostaminia G, Peck JD, Quiroz LH, Shobeiri SA: How well can levator ani muscle morphology on 3D pelvic floor ultrasound predict the levator ani muscle function? *Int Urogynecol J*, 2015; 26: 257–62
10. Raizada V, Bhargava V, Jung SA et al: Dynamic assessment of the vaginal high-pressure zone using high-definition manometry, 3-dimensional ultrasound, and magnetic resonance imaging of the pelvic floor muscles. *Am J Obstet Gynecol*, 2010; 203: 171–72
11. Ying T, Li Q, Xu L et al: Three-dimensional ultrasound appearance of pelvic floor in nulliparous women and pelvic organ prolapse women. *Int J Med Sci*, 2012; 9: 894–900
12. Chaturvedi S, Bansal R, Ranjan P et al: Trans-vaginal total pelvic floor repair using customized prolene mesh: A safe and cost-effective approach for high-grade pelvic organ prolapse. *Indian J Urol*, 2012; 28: 21–27
13. Li YQ, Geng J, Tan C et al: Diagnosis and classification of female stress urinary incontinence by transperineal two-dimensional ultrasound. *Technol Health Care*, 2017; 25: 859–66
14. Chang TC, Hsiao SM, Chen CH et al: Utilizing preoperative 20-minute pad testing with vaginal gauze packing for indicating concomitant midurethral sling during cystocele repair. *Eur J Obstet Gynecol Reprod Biol*, 2014; 172: 127–30
15. Delancey JO: Why do women have stress urinary incontinence? *NeuroUrol Urodyn*, 2010; 29(Suppl. 1): S13–17
16. DeLancey JO, Trowbridge ER, Miller JM et al: Stress urinary incontinence: Relative importance of urethral support and urethral closure pressure. *J Urol*, 2008; 179: 2286–90
17. Al-Saadi WI: Transperineal ultrasonography in stress urinary incontinence: The significance of urethral rotation angles. *Arab J Urol*, 2016; 14: 66–71
18. 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: 54–57
19. Lovegrove JR, Peng Q, Stokes M et al: Mechanisms of pelvic floor muscle function and the effect on the urethra during a cough. *Eur Urol*, 2010; 57: 1101–10
20. Brandt FT, Lorenzato F, Albuquerque CD et al: Tension-free vaginal tape versus lata fascia sling: The importance of transvulvar ultrasound in the assessment of relevant anatomical parameters in treatment of women with stress urinary incontinence. *Indian J Urol*, 2009; 25: 62–67
21. Schroeder R, de Mooij K, Groen L et al: Static and dynamic ultrasound imaging to visualize the bladder, bladder neck, urethra, and pelvic floor in children with daytime incontinence. *Front Pediatr*, 2017; 5: 247
22. Macura KJ, Thompson RE, Bluemke DA, Genadry R: Magnetic resonance imaging in assessment of stress urinary incontinence in women: Parameters differentiating urethral hypermobility and intrinsic sphincter deficiency. *World J Radiol*, 2015; 7: 394–404