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Original article

Multiparametric Study of Transperineal Ultrasound in Evaluating Females With Stress Urinary Incontinence

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Abstract

Background: Urinary stress incontinence (USI) is defined as involuntary leakage of urine. Two times as many women as men experience incontinence. To assess urinary incontinence and its subtypes, many investigations are used. The primary diagnostic imaging modality used for examining the lower urinary tract in cases diagnosed with urine leakage is transperineal ultrasonography. It has been demonstrated that it helps to increase the precision of morphological and functional abnormality when combined with the history, clinical examination, and urodynamics. **Patients and methods:** This case control study included two groups; 17 female complaining of USI and 17 healthy females examined by trans-perineal ultrasonography. The difference of both α and β angles at rest and at stress as well as other urethral parameters. **Results:** The alpha and beta angles at stress and the difference between rest and stress (R alpha and R beta) were significantly higher in cases than controls. No detectable significant difference between both groups regarding alpha angle at rest & beta angle at rest. No appreciable significant difference between the study groups as regards the bladder wall, urethral length, width, Pubo-urethral distance at rest and at stress. **Conclusion:** Transperineal ultrasonography can assess stress incontinence by measuring different angles and other parameters. There were no difference between cases and controls during rest for both alpha and beta angles while a significant value showed up during stress. The other parameters showed no significant value between two groups.

1. Introduction

Urinary bladder is a hollow pelvic structure that resembles a sac [1]. Good compliance of the UB means its ability to be filled with large volume of urine without any substantial rise in pressure, also generates an adequate pressure to aid urine expulsion [2].

Female urethra is considerably smaller than male urethra. It usually measures 4 cm long. It passes below the symphysis pubis. It begins at the bladder neck and curls slightly forward before continuing on to external urethral meatus [2]. It acts as a urine-conducting tube [3].

The International Continence Society (ICS) defines the SUI as “the symptom of involuntary leakage of urine on any physical effort , sneezing or even coughing [4]. SUI is considered a hygienic and social problem that impairs female’s life and has a major negative impact on life quality as it significantly deteriorates patients' physical, psychological, and social wellbeing [5,6, 7].

The prevalence of UI at women with older ages has been studied in many researches; with an overall prevalence of 14% in US studies, 37% in European populations, 13% in different regions of Asia, and in Africa 45.3%. Regarding Middle Eastern countries, it was found to be 52% [8].

Urine incontinence subtypes include stress, urge, and mixed incontinence [9]. The most frequent type of UI in women is stress urinary incontinence, in which involuntary drippling of urine during any physical activity (49%) occurs. This is followed by urge urinary incontinence (21%), that is characterized by involuntary contractions of the detrusor muscle during the phase of filling that can occur spontaneously or be provoked and cannot be completely suppressed by the patient; and mixed urinary incontinence (29%), which is complex of UUI, and SUI symptoms. [10]. SUI is defined as unintentional urine leaking caused by coughing, lifting, sneezing, or laughing. [11].

Urinary incontinence (UI) occurs more frequent in elderly population. UI in women is frequently thought to be caused by parity, vaginal delivery and pregnancy. During menopause, the urogenital tract experiences atrophic changes that make it more susceptible to urinary tract infections and may result in UI. Chronic illnesses and obesity also have a role in development of UI [10].

Stress urinary incontinence (SUI) is linked to hypermobility of the urethra and insufficiency of the intrinsic sphincter. The most frequent causes are loss of urethral support and compression after pelvic surgery, or trauma, childbirth, chronic elevation of intra-abdominal pressure due to chest disorder, excessive straining, vigorous lifting, and aging with hypoestrogenic state [6].

There are variable ways to diagnose SUI such as urodynamic test, cysto-urethrography, ultrasonography and MRI [12]. The use of a video urodynamic examination are not offered by all institutions. Some ladies find this diagnostic instrument to be very uncomfortable [7].

Ultrasonography is the primary method used to examine the lower urinary tract's anatomy and functional in patients with history of urine leakage. Ultrasonography is a simple, no invasive, non hazardous and affordable method that most patients find to be comfortable for the examination of urine incontinence that has results comparable or even better than other radiologic approaches [13].

Transperineal ultrasonography is very helpful in assessment of bladder neck and proximal urethral mobility [13]. In transperineal ultrasound, the bladder, its base, symphysis pubis and also the urethrovesical (UV) junction have been well visualized. In contrast to urodynamic evaluation, this technique enables the lesion causing the incontinence to be seen in real time. For the past 20 years, it has been employed in place of traditional radiological methods to evaluate the dynamic changes in the UV junction and the proximal part of the urethra. It can detect early changes in urethral muscular wall thickness and its reduced size in urinary incontinence cases [7]. Also, adequate assessment of the urethral hypermobility which is an important factor for successful surgical management can be evaluated **[14].**

Ultra-high-resolution MRI of the urethra in females is now achievable because of development of the endourethral coil. [5]. However, MRI has not been frequently used in the research of urine incontinence. [7].

The aim of the current study was to assess all parameters and findings of trans-perineal ultrasonography for females presenting with stress urinary incontinence. This was done by measuring the difference of both α and β angles at rest and at stress as well as other urethral parameters.

2. Patients and Methods:

This was a case control study performed in radiology department of university hospital from November 2020 to October 2022 involving 17 incontinent women and 17 continent women as their control. Cases were referred from outpatient clinics of urology, gynaecology & obstetric departments.

2.1 Inclusion criteria:

1. Women complaining of primary stress urinary incontinence.
2. Women as controls were age and body mass index matched the cases group.

2.2 exclusion criteria:

1) Patients with previous pelvic surgery.
2) Recurrent cases of SUI.
3) Mixed or urge urinary incontinence.
4) Urinary tract anomalies.
5) Pregnant women.

2.3 All participants were subjected

1. Full history taking;

Detailed history, past medical, gynecological, obstetric and surgical history. Symptoms related to urogynecological disorders (e.g. dysuria, nocturia, frequency, condition precipitating SUI like sneezing, laughing, coughing, its duration and severity).

The NHANES survey included questions were used to establish type as well as severity of urinary incontinence.

2. Laboratory test: Urine analysis to exclude any signs of infection.

3. Radiological investigations:

a) Trans-abdominal ultrasound for all participants to exclude any pelvic abnormalities as lateral cystocele (prolapsed bladder), urinary bladder diverticulum and any pelvic masses.

b) Transperineal ultrasonography:

Voluson 730 pro US machine - (GE Medical Systems, Austria) using 3.5 MHz 2D electronic convex array probe was used for the TPUS. procedure. There was no preparation necessary, apart from urinary bladder partial filling for better visualization of pelvic anatomy included in the study. Participants were lying in lithotomy position. After gel application over a covered probe with a glove, the probe was situated interlabial in a sagittal orientation. The symphysis pubis lower edge was used as a reference point to acquire views of the symphysis pubis, urethra and bladder. Orientation of image and screen display were standardized, so that the symphsis pubis appeared at the right side of the screen. The bladder, UV junction, and the urethra were visualized during rest, then the image was frozen and put on one side of the screen. The other half of the screen, we asked female cases to do Valsalva's manoeuver and then frozen the image again, put on the other half of the screen.

The following items were measured (figure 1):

1) The posterior urethro-vesical angle (PUV) or β-angle which is known as the formed angle between the urethral axis and a line near the bladder neck which is in line with the posterior edge of the bladder base. It was measured during rest and at straining.

2) The angle of urethral inclination or α-angle measured at resting and during straining; that

is defined as angle between the urethral axis and the central line of symphysis pubis.

3) R alpha and R beta: difference between both angles during a Valsalva's manoeuvre minus the angle at rest was calculated.

4) UB wall thickness.

5) Urethral width.

6) Urethral length.

7) Pubo-urethral distance at rest and at stress.

Ethical consideration:

Approval of the current study by faculty of medicine ethical Committee, no FMBSUREC/03112020/Mohammad was done. Informed consents were signed from the participants. They were assured that their data were confidential.

Statistical methodology

IBM running the social science statistics package SPSS 25 were used for the analysis; Mean, standard deviation, and range were used to characterize quantitative variables. Quantitative and qualitative breakdown of the relevant factors. Quantitative variables in parametric data were compared using the unpaired t-test, while categorical variables were compared using the chi-squared test. Receiver The best cutoff of many MRI parameters for detecting urine incontinence was determined using an operating characteristic curve analysis. The cutoff for significance was set at P 0.05.

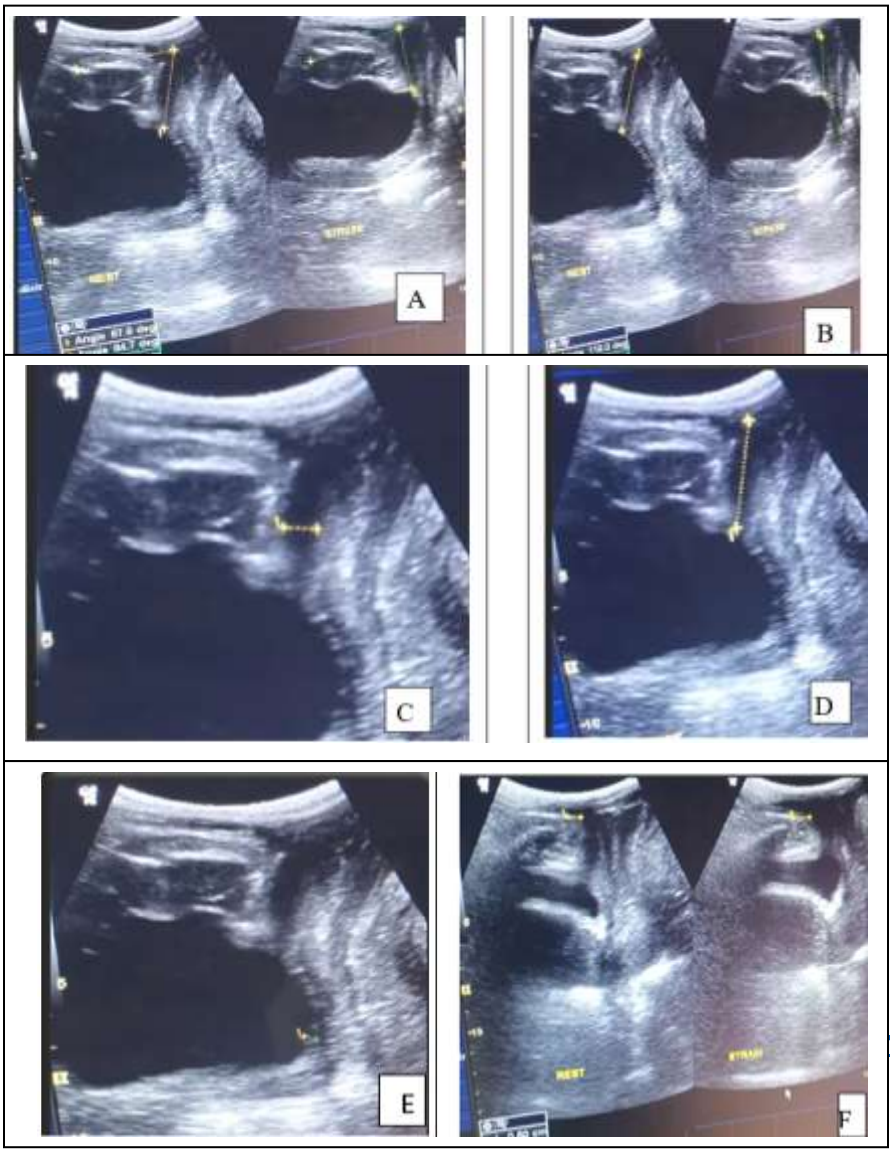

Figure 1. Female patient, 30 year old, complaining of SUI, Transperineal ultrasound showed; Alpha angle at rest was 67.6 degrees while at stress was 84.7 degrees with difference between them 17.1 degrees (A). Beta angle at rest was 119 degrees while at stress was 154.3 degrees with difference 35.3 degrees (B). Urethra was 3.4 cm length and 7 mm width (C,D). Bladder wall thickness was 3 mm (E). The pubo-urethral distance at rest was 5 mm while at stress was 8 mm (F).

3. Results:

This case control study was conducted to assess findings of trans-perineal ultrasonography in women presenting with SUI, by measuring multi- parameters in a group of continent women and another group of women with SUI symptoms.

Table (1) Demographic data of the study groups:

items	Cases (no=17)	Controls (no=17)	P-value
Age (years)	40.2±12.7	36.2±14	0.383
BMI (Kg/m2)	33.3±6.2	32.1±6.9	0.596
Gravidity (number)	4±2	4±2	>0.999

Table (1) showed no significant difference in the demographic data of the two groups. (P-value>0.05).

Table (2) Disease characteristics of cases:

items	Cases (no=17)
Disease duration	4.9±2 years
Incontinence during cough	15(88.2%)
Incontinence during sneezing	15(88.2%)
Incontinence during laugh	9(52.9%)

Table (2) showed that the mean disease duration was 4.9±2 years and 88.2% were incontinent during cough and sneezing, 52.9% were incontinent during laugh.

Table (3) Comparison between the cases and controls regarding the alpha angles:

Alpha angles (degrees)	Cases (no=17)	Controls (no=17)	P-value
At rest	68.1±20.5	63.6±15.5	0.481
At stress	91.4±21.6	70.1±15	0.002*
Difference	23.9±7.6	6.5±3.3	<0.001*

P-value is significant

Table (3) showed:

- No significant difference between both groups regarding alpha angle at rest (P-value>0.05).
- The alpha angle at stress and the difference between rest and stress (R alpha) were significantly higher in cases than in controls (P-value<0.001).

Table (4) Comparison between the groups of the study regarding the beta angles:

Beta angles (degrees)	Cases (no=17)	Controls (no=17)	P-value
At rest	122.2±24.7	116.8±23.4	0.520
At stress	149.4±28.4	122.1±23.6	0.005*
Difference	27.1±15.6	6.1±3.3	<0.001*

P-value is significant

This table (4) revealed:

- No significant difference seen among both groups regarding beta angle at rest (P-value>0.05).
- The beta angle at stress and the difference between rest and stress (R beta) were significantly higher in cases than controls (P-value<0.001).

Table (5) Comparison between the two groups regarding bladder wall & urethral parameters

Items	Cases (no=17)	Controls (no=17)	P-value
Bladder wall (mm)	4.3±1	3.7±0.9	0.058
Urethral length (cm)	3.5±1.5	3.1±0.4	0.299
Urethral width (mm)	7.5±2.7	6.0±1.5	0.060
Pubo-urethral distance at rest (mm)	9.5±3.2	8.4±3	0.282
Pubo-urethral distance at stress (mm)	13.1±4.1	10.6±4.7	0.105

Table (5) showed no significant difference between the study groups regarding the bladder wall, urethral length, width, Pubo-urethral distance at rest and at stress (P-value>0.05).

Table (6) Binary logistic regression analysis for prediction of presence stress incontinence from different characteristics:

Independent variables	**P-value**	**OR**	**95% C.I.for OR**	
			Lower	**Upper**
alpha angle at stress (degrees)	0.044*	1.070	1.002	1.143
beta angle at stress (degrees)	0.016*	1.061	1.011	1.113
age (years)	0.539	1.031	.935	1.138
gravidity/parity (number)	0.596	1.173	.651	2.114

**P-value is significant*

Table (6) showed that alpha and beta angles had a significant role in increasing the probability of acquisition of incontinence after adjustment for age and gravidity.

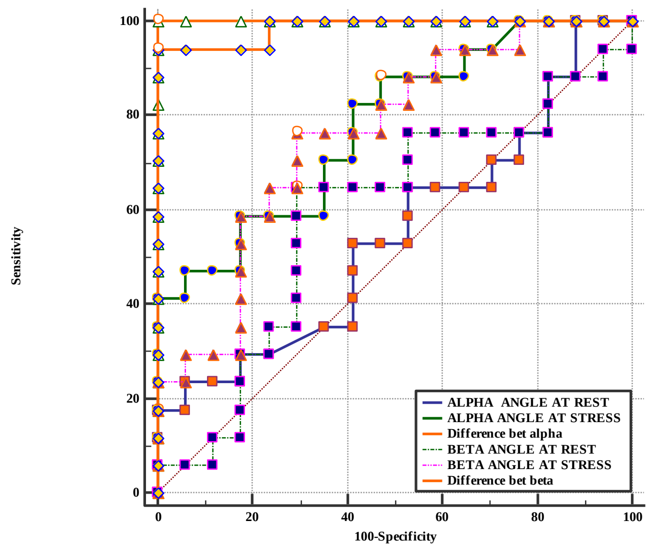

Figure2. ROC curves analysis for prediction of incontinence

Table (7) data obtained from ROC curves:

	Alpha at rest	**Alpha at stress**	**Difference of alpha**	**Beta at rest**	**Beta at stress**	**Difference of beta**
AUC	0.574	0.777	1.000	0.588	0.758	0.986
P-value	0.643	<0.001*	<0.001*	0.385	0.002*	<0.001
Cut off	>66.5	>72.7	>10.1	>117.5	>124.2	>10.1

**P-value is significant.*

Table (8) sensitivity, specificity, positive predictive value and negative predictive value of alpha and beta angles at rest and stress and the difference between rest and stress in prediction of incontinence:

	Alpha at rest	**Alpha at stress**	**Difference of alpha**	**Beta at rest**	**Beta at stress**	**Difference of beta**
Sensitivity	52.9%	82.4%	100%	64.71%	76.5%	94.1%
Specificity	58.82%	58.8 %	100 %	70.6 %	70.6 %	100 %
PPV	56.2%	66.7 %	100 %	68.7%	72.2%	100%
NPV	55.6 %	76.9 %	100 %	66.7%	75%	94.4 %

This table showed that the alpha and beta angles at stress, the difference between the angles at stress and rest have a significant role in prediction of stress incontinence. The difference of alpha angle can significantly predict incontinence at a cut off value >10.1^o , with sensitivity 100%, specificity 100%, PPV 100%, NPV 100%, followed by the difference of beta angle at a cut off value >10.1^o , with sensitivity 94.1%, specificity 100%, PPV 100%, NPV 94.4%.

Table (9) Correlation between age, BMI and disease duration with the measured parameters by US:

independent variables		age	BMI	disease duration	gravidity/parity
alpha angle at rest (degree)	**r**	.085	.093	.765**	-.258
	p-value	.747	.723	.001	.317
alpha angle at stress (degree)	**r**	.255	.125	.640**	-.159
	p-value	.324	.631	.008	.542
difference bet alpha (degree)	**r**	.399	-.019	-.175	.158
	p-value	.113	.941	.517	.546
beta angle at rest (degree)	**r**	-.008	-.155	.261	.234
	p-value	.977	.554	.330	.365
beta angle at stress (degree)	**r**	-.198	-.230	.280	.063
	p-value	.446	.374	.294	.809
difference bet beta (degree)	**r**	-.348	-.173	-.005	-.257
	p-value	.171	.507	.984	.319
bladder wall (mm)	**r**	.248	.050	.036	.155
	p-value	.336	.850	.894	.554
urethral length (cm)	**r**	-.024	-.073	-.208	.020
	p-value	.926	.779	.439	.939
PUD at rest (mm)	**r**	-.039	-.367	-.118	.024
	p-value	.882	.147	.664	.926
PUD (mm)	**r**	.168	-.246	-.134	-.014
	p-value	.518	.341	.620	.957
urethral width (mm)	**r**	.058	-.160	.160	-.072
	p-value	.826	.540	.555	.785

**P-value is significant*

This table showed that there was only linear positive correlation between the disease duration and alpha angle at rest and stress (P-value<0.001))

4. Discussion:

Transperineal ultrasound (TPUS) used for assessing urethral angles has been regarded as a crucial research technique for recording the functional and morphological characteristics of the pelvic floor pre and post surgical intervention [12]. Since 1980s, TPUS has been used as a complementary method to urethrocystography in SUI patients. It provides adequate data regarding the urethral and bladder changes with the benefit of radiation non-exposure [6].

The current study evaluated TPUS findings in females complaining SUI. 17 females were included in this study, complaining stress urinary incontinence and 17 females without incontinence as controls. The mean age of the study cases was 40.2±12.7 years with BMI 33.3±6.2 and gravidity 4±2 and that of controls was 36.2±14years with BMI 32.1±6.9 and gravidity 4±2. No significant difference was found among the study groups as regards their demographic data (p value respectively 0.383, 0.596 & >0.999).

The present study is compatible with [15] which included 40 females having SUI and also another 40 females as their controls. The mean ages of both cases and controls were 46.1±8.06 years and 43.2±5.39 years, respectively.

On the other hand, study [6] comprised thirty women complaining of SUI, with a mean (SD, range) age of 37.53 (12.54, 27–60) years and 30 controls with a mean (SD, range) age of 35.27 (10.19, 20–62) years.

In the current study, the alpha angle was found to be significantly different between the study group and control group only on straining (P 0.002). There was no significant difference in the alpha angle between patients with SUI and control group at rest. Compatible with our study, studies [13, 16 & 17] that had found alpha angle significantly different between the study cases and control group only on straining.

On the other hand, we had two diffident group results. Firstly studies [6, 18, 19, 20 & 21] had found that alpha angle significantly different between cases and controls at rest and on staining.

Secondly, studies [14&22] had found that no significant difference at alpha angle at rest and straining between SUI patients and control group.

In the present study, beta angle was found significantly different between the cases and the control group on straining (P < 0.005). No significant difference could be found in the beta angle between patients with SUI and control group at rest. Compatible with our study, study [13] that found beta angle had no significant difference between cases and controls at rest.

On the other hand of our study, studies [17, 6, 23, 12, 18, 19, 16, 14] had found that beta angle significantly different between patients with SUI and control group at rest and on stress.

The current study, the R alpha angle (23.9±7.6) and (6.5±3.3) & R beta angle (27.1±15.6) and (6.1±3.3) were highly significant among case and control groups (P<0.001). Compatible with our study, study [6] who found that the mean difference between alpha and beta angles values at rest and stress in cases of SUI were about twice those of the control group [mean(SD) R alpha angle 19.43 (12.76) and 10.53 (2.98), R beta angle 28.30 (12.96) and 16.33 (10.8)], which was statistically different.

Study [13] found that R α and R β were more significant in SUI participants than their controls (24.42±9.57 vs. 7.58±3.23) (p=0.000). Also, study [15] which found that R alpha angle was significantly bigger in the SUI group than in the continent group, [mean (SD) R alpha angle 37.89(20) and 15.59 (12.1)].

Study [24] had found R beta angle in SUI group (7.7 + 11.8) were clearly greater than (3.2 + 4.95) in the continent group, but not statistically different.

Estimation of R angles may overcome wide range of variability in the urethral angles values measured by different techniques of ultrasound, different operators experience and skills.

Regarding ROC curve, The Alpha angle at rest showed insignificant p value (0.643), sensitivity (52.9%), specificity (58.82%), PPV (56.2%), NPV (55.6%) & cut off value >66.5 degree.

Study [6] had found that the threshold value of >46.5 for the alpha angle at rest, sensitivity and specificity (96.7% and 100%, respectively).

Alpha angle at stress showed significant difference between case and control groups (P <0.001), sensitivity (82.4%), specificity (58.8%), PPV (66.7%), NPV (76.9%) & cut off value (>72.7degree).

Study [6] had found that the threshold value >58.5 for the alpha angle at stress, Sensitivity and specificity of 96.7%.

Difference between alpha at rest and stress showed significant difference between cases and controls (P< 0.001), sensitivity (100 %), specificity (100%), PPV (100%), NPV (100%) and cut off value (>10.1 degree)

Study [13] found the cut-off point that was determined for the R α in diagnosis of stress incontinence is >16°. The sensitivity of this value was found to be 80% and specificity 98%.

Beta angle at rest showed insignificant p value (0.385), sensitivity (64.71%), specificity (70.6%), PPV (68.7%), NPV (66.7%) and cut off value (>117.5degree).

Study [6] found that beta angle threshold value was >119 at rest and with lower sensitivity and specificity (63.3% and 60% respectively).

Study [17] found the beta angle threshold value > 120 degree at rest, sensitivity 95 % and specificity 97.4 %, PPV 98.2 % & NPV

95.4 %. Beta angle at stress showed significant difference between cases and controls (P =0.002), sensitivity (76.5 %), specificity (70.6%), PPV (72.2%), NPV (75%) and cut off value (>124.2 degree).

Study [6] found that beta angle threshold value was >141.5 at stress and with lower sensitivity and specificity (73.3% and 80% respectively)

Study [24] had found that R beta angle was greater in the group of incontinent females (7.7 + 11.8) than in control group (3.2 + 4.95), and the difference was statistically significant (P=0.014), The cut-off level of R beta angle was assumed to be 8 degree, with sensitivity 44%, specificity 88%, PPV 78% and NPV 61%.

On the present study, bladder wall thickness showed no significant changes between case and control groups. Studies [14, 11 & 12] were compatible with our result regarding the bladder wall thickness.

In this study, no significant variations were also detected regarding urethral width between case and control groups. Study [14] were compatible with our result showing no statistical differences between their study groups. Study [25] was compatible with our result.

The current study, the PUD showed no significant difference on rest and straining between case group and control group. On the other hand, Studies [18 & 14] had found that the PUD was significantly different between cases and controls at both rest and straining.

Eventually, different volumes of urine filling the UB might give different results by ultrasonography. Also, a lot of variables, such as parity, BMI, race, and delivery type, could alter the threshold value of the main variables investigated.

5. Conclusion and Recommendations:

Transperineal ultrasonography can assess stress incontinence by measuring different angles and other parameters. There were no difference between cases and controls during rest for both alpha and beta angles while a significant value showed up during stress. The other parameters showed no significant value between two groups.

We recommended to change only one item from the characteristics of the patients e.g. age, BMI, race or parity to see how it will affect the disease.

Also, more researches about differences between angles will be helpful.

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