RESEARCH PAPER

Evaluating accuracy of the Retrovesical (β) Angle in Transperineal Ultrasound for detection of Stress Urinary Incontinence diagnosed by Urodynamic test

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ABSTRACT

Background: Stress urinary incontinence (SUI) is a prevalent ailment in females that negatively affects their quality of life. Transperineal ultrasound (TPUS) is a noninvasive, accessible, and cost-effective method for evaluating anatomical changes associated with SUI.

Aim of the Work: To provide better, noninvasive, cost-effective diagnostic method for SUI using TPUS parameters.

Patients and Methods: This comparative cross-sectional research was performed at the Department of Obstetrics & Gynecology, Suez Canal University Hospital, from January 2023 to December 2024. The research included 84 women divided into two groups: 42 women with SUI confirmed by urodynamic study and 42 controls without urinary incontinence. All participants underwent clinical examination, laboratory investigations, detailed history taking & TPUS to assess the retrovesical (β) angle at rest & throughout the Valsalva maneuver, bladder neck funneling (BNF), bladder wall thickness (BWT), postvoid residual urine (PVR), bladder neck descent (BND) & the presence of cystocele.

Results: Transperineal ultrasound showed statistically significant differences among severity groups in β angle at rest and throughout the Valsalva maneuver, bladder neck descent, and bladder wall thickness in both empty and full bladder states. Bladder neck funneling differed significantly only throughout the Valsalva maneuver. For diagnosis, a β angle cutoff of 130° during the Valsalva maneuver yielded 88.10% sensitivity and 90.48% specificity, while a bladder neck descent cutoff of 11 mm yielded 85.17% sensitivity and 95.24% specificity.

Conclusion: particularly measurement of the retrovesical β angle, Transperineal ultrasound & bladder neck descent, may be a useful noninvasive diagnostic tool for SUI. Further studies involving larger populations are needed to establish standardized diagnostic thresholds and clarify its role in clinical practice.

Keywords: Stress urinary incontinence; transperineal ultrasound; retrovesical angle; bladder neck descent; bladder neck funneling

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INTRODUCTION

SUI is known as leakage of urine throughout physical activity that elevates intra-abdominal pressure as sneezing, coughing, lifting, or laughing, which may influence patient's quality of life including her social and sexual life, it is the predominant occurrence type of incontinence occurring in 50% of women complaining of urinary leakage [(1)]

The most significant factor for the occurrence of SUI is old age, with weakness of pelvic floor muscles & laxity of the urethral musculature, particularly of the external sphincter [(2)]. Additionally, the hormonal fluctuations during menopause are an important factor in SUI [(3)].

However, many risk factors for SUI are identified like Ethnicity or race & a hereditary inclination toward SUI. Obesity is recognized as a changeable risk factor that results in elevated intra-abdominal pressure, thereby causing a deterioration of the pelvic floor's innervation and muscles. [(3)].

Any other factors that result in elevated intra-abdominal pressure, like constipation & chronic cough, can have a secondary function in inducing stress urinary incontinence [(1)].

Factors of obstetric are significant in SUI, like twin & multiple pregnancies, vaginal delivery, multiparity & traumatic deliveries [(4)].

Diabetes mellitus has been recognized as a significant risk factor for UI. It usually occurs first due to hyperglycaemia then Microvascular injury to the nerve supply of the bladder & urethral sphincter, bladder instability, urinary retention, sphincter impairment & increased postvoid residual urine volume that contribute to overflow urinary incontinence, persistent bacterial colonization & UTIs [(2)].

In line with the 2005 International Consultation on Incontinence, the diagnosis of SUI relies on assessment of quality of life, medical history, local & general physical examinations [(5)]. Nevertheless, the clinical assessment might lack sufficient precision. Numerous imaging techniques, including cystourethrography, pelvic floor ultrasonography & magnetic resonance imaging, are recommended for diagnostic purposes. Nonetheless, there exists no standard to choose the most suitable imaging modality. [(6).]

Bladder neck mobility associated with the functional soundness of the tissues encircling the proximal urethra, can be detected by transperineal ultrasound showing abnormal motion of the bladder neck throughout coughing or Valsalva maneuver [7].

With exertion, the proximal segment of the urethra may execute a rotating motion in a posterior-inferior orientation. The extent of this motion can be evaluated by gaging the angles of inclination among a designated fixed axis & the proximal urethra. The posterior urethrovesical angle (8); established among a tangent line to the proximal half of the urethra & a tangent line to the lowest posterior part of the bladder base, has lately been utilized as a criterion [9].

Our study aimed to provide better, noninvasive, cost-effective diagnostic method for stress urinary incontinence using transperineal ultrasound parameters.

PATIENTS AND METHODS

This comparative cross-sectional research was done in the department of Obstetrics & Gynecology, Suez Canal University hospital, Women attending at the outpatient clinic of the department of Obstetrics & Gynecology complaining of stress urinary incontinence between January 2023 to December 2024.

Inclusion criteria: The inclusion criteria for cases were women aged 30–65 years with a history of vaginal delivery who complained of SUI based on symptoms & confirmed by urodynamic study [10]. The control group included women aged 20–65 years with a vaginal delivery history and no urinary incontinence.

Exclusion criteria: The exclusion criteria for both cases and controls were a pelvic surgery history, such as hysterectomy; previous cesarean delivery; pelvic masses or malignancies of the bladder, ovary, uterus, or rectum; previous pelvic floor mesh insertion; a history of pelvic radiation therapy; diabetes mellitus; urinary tract infection; urge or mixed urinary incontinence; urethral or bladder anomalies; neuromuscular defects involving the muscles; pregnancy or being within six weeks postpartum; and pelvic organ prolapse extending beyond the hymen (grades III and IV).

Ethical consideration: The study adhered to the relevant ethical considerations. Permission was obtained from the responsible authorities, and approval was granted by the Research Ethics Committee of the Faculty of Medicine, Suez Canal University, before the commencement of fieldwork. Informed consent was obtained from all participants after providing a clear and simple clarification of the research's aims & procedures. Participants were made aware of their entitlement to decline participation or exit the study at any moment without justification and without facing any negative repercussions for their work. No harmful procedures or maneuvers were performed. Participants' data were kept confidential, and coding was used during data handling and transfer to protect their privacy. Finally, the study results were disseminated to relevant stakeholders.

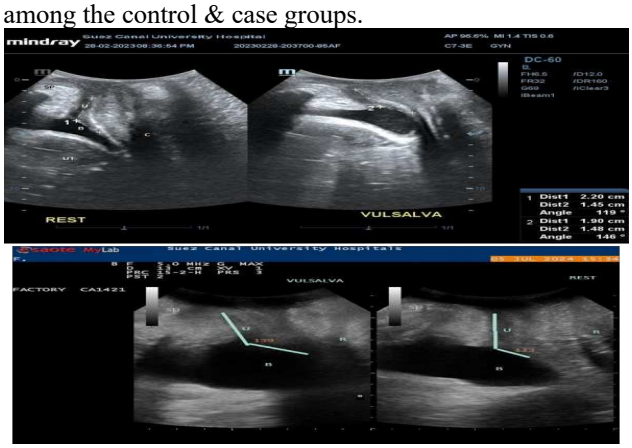
Methods

A detailed medical and obstetric history was obtained, including demographic data, menstrual history, previous surgeries, chronic illnesses, and risk factors for urinary incontinence. Incontinence type, severity, associated symptoms, triggering factors, and relevant medications were recorded. Severity was assessed applying the Sandvik Severity Index, calculated via multiplying leakage frequency by the amount of urine lost [11].

General and abdominal examinations were performed, followed by pelvic examination to assess pelvic organ prolapse, involving rectocele, enterocele, uterine prolapse, cystocele, and perineal laxity. The cough stress test was done with a partially filled bladder (approximately 150 mL), with urine leakage during coughing or the Valsalva maneuver indicating a positive result. The Marshall–Bonney test was also performed by supporting the bladder neck during coughing or straining; the absence of leakage with support and its presence without support indicated stress urinary incontinence associated with urethral hypermobility.

Investigations: Laboratory investigations included urinalysis, urine culture and sensitivity, and fasting blood glucose. Multichannel cystometry was performed to assess bladder and abdominal pressures, detrusor activity, bladder sensation, and maximum capacity. Abdominal leak point pressure was measured during the Valsalva maneuver following filling the bladder with approximately 200 milliliters of saline. Urine leakage confirmed stress urinary incontinence, while detrusor overactivity was excluded. Transperineal ultrasonography was subsequently performed [12].

Transperineal ultrasonography was done in the lithotomy position using a Mindray DC-60 ultrasound system with a 3.5-megahertez transducer, with the bladder partially filled (approximately 150 milliliters). The posterior urethrovesical angle was measured at rest & during the Valsalva maneuver by assessing the relationship among the bladder base & proximal urethra [10]. Bladder neck funneling was assessed with & without straining, while thickness of bladder wall was measured in both full and empty bladder states, using cutoff values of 3 mm and 5 mm, correspondingly. Bladder neck descent during maximal Valsalva maneuver was measured relative to the inferoposterior margin of the pubic symphysis, with a cutoff value of 11 mm [13]. After bladder evacuation, postvoid residual urine volume was measured, with a cutoff value of 50 mL [14]. The existence of cystourethrocele or cystocele was also documented, and all ultrasonographic findings were compared among the control & case groups.



Figures 1. show retrovesical (β) angle measurements in 2 cases of SUI show values above cut off point at rest and vulsalva. Sp: symphysis pubis u: urethera B: bladder R: rectum C: cervix UT: uterus.

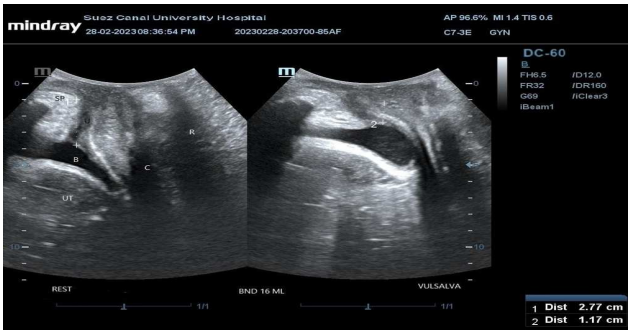


Figure 2. show BND measurement in a case of SUI Sp: symphysis pubis u: urethra B: bladder R: rectum C: cervix UT: uterus.

RESULTS

Table 1 show comparison among controls & cases in demographic information showing no statically significant difference in age, parity, menstruation, occupation or address. However, there was statically significant variance in BMI among controls and cases **(Table 1).**

Table 2 shows comparative analysis among 2 examined groups in line with β angle at rest

and β angle at vulsalva the mean β angle at rest was 115.76 ± 5.23° in cases compared to105.88 ± 3.27°. β angle at vulsalva is 142.31 ± 8.05° in cases and 121.86 ± 4.76° in controls with high statically significance difference between cases and controls in β angle measurement at rest and vulsalva maneuver **(Table 2).**

Table 3 shows Comparison among the 2 examined groups in line with bladder neck & bladder wall thickness in which 16.7% of cases showed bladder neck funneling at rest compared to 2.4% of controls with not statically significant variance among both groups. However, there was statically significance difference between both groups when compared during vulsalva maneuver in which 31% of cases showed bladder neck funneling compared to 7.1% in controls. Comparing both groups according to bladder neck descent demonstrated that there was high statically significant variance between cases and controls. The mean descent in cases was 16.10 ± 4.30 ml compared to 7.19 ± 2.17 ml in control group. No statically significant difference between cases and controls according to bladder wall thickness either in full or empty bladder. **(Table 3).**

Table 4 shows Comparison among 2 examined groups in line with post void residual urine in which 31.79 ± 11.30 ml in cases compared to 26.69 ± 9.82 ml in control group with statically significant variance among both groups **(Table 4).**

Table 5 illustrates a comparison between the three groups according to transperineal ultrasound findings. There was a highly statistically significant variance between the three groups in terms of β angle measurements at rest and throughout the Valsalva maneuver, with mean values at rest of 109.7 ± 2.45°, 115.2 ± 4.07°, and 120.1 ± 3.53° in mild, moderate, and severe/very severe cases, respectively. During the Valsalva maneuver, the corresponding mean β angles were 132.3 ± 5.34°, 141.3 ± 5.50°, and 149.5 ± 3.94°, respectively. Similarly, bladder neck descent showed a statistically significant variance between the three groups, with mean values of 12.11 ± 4.62 mm, 15.61 ± 2.75 mm, and 19.07 ± 3.59 mm in mild, moderate, and severe/very severe cases, respectively. Regarding bladder neck funneling, there was a statistically insignificant variance among the groups at rest; however, a statistically significant variance was detected during the Valsalva maneuver, with no mild cases showing funneling compared to 22.2% of moderate cases and 60% of severe/very severe cases. Additionally, bladder wall thickness measurements in both empty and full bladder states showed statistically significant variances between the three groups **(Table 5).**

Table 6 shows Diagnostic performance for β angle at rest, β angle at vulsalva and bladder neck descent in which: β angle at rest at cut off value 110° show sensitivity 76.19% specificity 90.48% positive predictive value 88.9% and negative predictive value was 79.2%. While β angle at vulsalva at cut off value 130° show sensitivity 88.10% specificity 90.48% positive predictive value 90.24% and negative predictive value was 88.37%. Bladder neck descent at cut off value 11 ml show sensitivity 85.17% specificity 95.24% positive predictive value 94.74% and negative predictive value was 86.96% **(Table 6).**

Table (1): comparative analysis among 2 examined groups in line with demographic information

variables	Cases (n=42)	Controls (n=42)	Test of Sig	p
Age (years)				
Min. – Max.	33.0 – 59.0	23.0 – 59.0	t = 0.850	**0.398**
Mean ± SD.	45.71 ± 7.41	44.17 ± 9.18		
Median (IQR)	45.50 (40.0 – 52.0)	46.0 (38.0 – 50.0)		
BMI (kg/m^2)				

Min. – Max.	27.40 – 34.60		23.90 – 33.60		$t = 3.346^*$	**0.001***
Mean ± SD.	30.93 ± 2.12		29.11 ± 2.82			
Median (IQR)	30.50(29.50 – 32.60)		28.95(26.80 – 31.70)			
Parity						
Min. – Max.	2.0 – 6.0		1.0 – 6.0		$U = 749.0$	**0.216**
Mean ± SD.	3.40 ± 1.11		3.05 ± 1.17			
Median (IQR)	3.0 (3.0 – 4.0)		3.0 (2.0 – 4.0)			
Menstruation						
Menstruating	28	66.7	30	71.4	$\chi^2 = 0.223$	**0.637**
Menopause	14	33.3	12	28.6		
Address						
Rural	22	52.4	20	47.6	$\chi^2 = 0.190$	**0.663**
Urban	20	47.6	22	52.4		
Occupation						
House wife	28	66.7	27	64.3	$\chi^2 = 0.053$	**0.818**
Worker	**14**	**33.3**	**15**	**35.7**		

IQR: **Inter quartile range** SD: **Standard deviation** **t: Student t-test** **U: Mann Whitney test** □2: **Chi square test** **FET: Fisher Exact test**

p: p value for comparing the two examine groups

*: Statistically significant at p -value not more than 0.05

Table (2): comparative analysis among 2 examined groups in line with β angle at rest & β angle at vulsalva

β angle	Cases (number = 42)	Controls (number = 42)	T	p
β angle at rest (°)			10.381*	**<0.001***
Min. – Max.	107.0° – 127.0°	101.0° – 114.0°		
Mean ± SD.	115.76 ± 5.23°	105.88 ± 3.27°		
Median (IQR)	116.0° (112.0° – 120.0°)	105.0° (104.0° – 108.0°)		
β angle at vulsalva (°)			14.173*	**<0.001***
Min. – Max.	125.0° – 156.0°	115.0° – 134.0°		
Mean ± SD.	142.31 ± 8.05°	121.86 ± 4.76°		
Median (IQR)	**144.0° (137.0° – 149.0°)**	**121.5° (118.0° – 124.0°)**		

Table (3): comparative analysis among 2 examined groups in line with bladder neck and bladder wall thickness

Bladder parameters		Cases (n = 42)		Controls (n = 42)		Test of Sig	P
		No.	%	No.	%		
Bladder neck descent	Funneling at Rest						
	No	35	83.3	41	97.6	$\chi^2 = 4.974$	FEp = 0.057
	Yes	7	16.7	1	2.4		
	Funneling at Vulsalva						
	No	29	69.0	39	92.9	$\chi^2 = 7.721^*$	0.005*
	Yes	13	31.0	3	7.1		
	Descent (in ml)					U = 53.50*	<0.001*
	Min. – Max.	8.0 – 25.0		4.0 – 14.0			
	Mean ± SD.	16.10 ± 4.30		7.19 ± 2.17			
	Median (IQR)	16.0 (14.0 – 18.0)		7.0 (6.0 – 8.0)			
Bladder wall thickness	Full bladder						
	Min. – Max.	2.40 – 3.80		2.40 – 3.80		U = 865.00	0.879
	Mean ± SD.	3.06 ± 0.45		3.08 ± 0.40			
	Median (IQR)	3.05 (2.60 – 3.50)		3.10 (2.80 – 3.40)			
	Empty bladder						
	Min. – Max.	4.30 – 7.0		4.30 – 6.80		U = 868.50	0.904
	Mean ± SD.	5.44 ± 0.74		5.39 ± 0.66			
	Median (IQR)	**5.30 (4.80 – 6.0)**		**5.35 (4.80 – 5.90)**			

Table (4): comparative analysis among 2 examined groups in line with post void residual urine

	Cases (n = 42)	Controls (n = 42)	U	p
Post void residual urine (ml)			608.50*	0.014*
Min. – Max.	15.0 – 55.0	14.0 – 55.0		
Mean ± SD.	31.79 ± 11.30	26.69 ± 9.82		
Median	**29.0 (24.0 – 36.0)**	**24.0 (20.0 – 32.0)**		

(IQR)				

Table (5): Relation between Sandvik severity index and Bladder finding by transperineal ultrasound in cases group (n = 42)

	Sandvik severity index						Test of Sig.	p
	Mild (n=9)		Moderate (n=18)		Severe+very			
	No.	%	No.	%	No.	%		
Bladder neck funneling at rest							FET=4.360	**0.097**
No	9	100.0	16	88.9	10	66.7		
Yes	0	0.0	2	11.1	5	33.3		
Bladder neck funneling at vulsalva							T=10.189*	**0.005***
No	9	100.0	14	77.8	6	40.0		
Yes	0	0.0	4	22.2	9	60.0		
Bladder neck descent (ml)							H=14.583*	**0.001***
Mean ± SD.	12.11 ± 4.62		15.61 ± 2.75		19.07 ± 3.59			
Median (Min.–Max.)	10.0 (8.0 – 22.0)		16.0 (10.0 – 21.0)		18.0(15.0 – 25.0)			
Bladder wall thicknes full bladder (ml)							H=11.629	**0.003***
Mean ±	2.70 ± 0.27		3.01		3.33			

SD.		±0.42	±0.41	*	
Median (Min.–Max.)	2.60(2.40 – 3.10)	0.42 (2.50 – 3.80)	3.50 (2.60 – 3.80)		
Bladder wall thicknes s empty bladder (ml)				H = 9.838 *	**0.007***
Mean ± SD.	4.87 ± 0.32	5.40 ± 0.70	5.83 ± 0.74		
Median (Min.–Max.)	4.80 (4.30 – 5.40)	5.30 (4.60 – 6.80)	6.0 (4.50 – 7.0)		
β angle at rest (°)				F = 23.892 *	**<0.001***
Mean ± SD.	109.7 ± 2.45°	115.2 ± 4.07°	120.1 ± 3.53°		
Median (Min.–Max.)	109.0 (107.0 – 113.0)	115.5 (109.0 – 122.0)	120.0 (115.0 – 127.0)		
β angle at vulsalva (°)				F = 34.507 *	**<0.0001***
Mean ± SD.	132.3 ± 5.34°	141.3 ± 5.50°	149.5 ± 3.94°		
Median (Min.–Max.)	**134.0 (125.0 – 139.0)**	**142.0 (129.0 – 150.0)**	**149.0 (144.0 – 156.0)**		

IQR: Inter quartile range SD: Standard deviation F: F for One way ANOVA test

H: H for Kruskal Wallis test χ^2: Chi square test

FET: Fisher Exact test

p: p value for comparing between different categories

Table (6):Diagnostic performance for β angle at rest, β angle at vulsalva and bladder neck descent

Diagnostic performance for β angle	AUC	p	95% C.I					
							PPV	NPV

β angle at rest	0.952	<0.001*	0.914–0.991	<110	76.19	90.48	88.9	**79.2**
β angle at vulsalva	0.985	<0.001*	0.968–1.0	>130	88.10	90.48	90.24	**88.37**
Bladder neck descent	**0.970**	**<0.001***	**0.941–0.999**	**>11**	**85.71**	**95.24**	**94.74**	**86.96**

AUC: Area Under a Curve

p value: Probability value

CI: Confidence Intervals

NPV: Negative predictive value

PPV: Positive predictive value

*: Statistically significant at $p \leq 0.05$

Figure 1. flow chart shows inclusion of study population.

DISCUSSION

This study demonstrated high statically significant variance among cases & controls for β angle and BND during rest and vulsalva maneuver the mean β angle at rest was115.76 ± 5.23° in cases compared to 105.88 ± 3.27°for controls. β angle at vulsalva is142.31 ± 8.05° in cases and 121.86 ± 4.76° in controls. The mean BND in cases was 16.10m± 4.30 ml compared to 7.19 ± 2.17 ml in control groups. According to other parameters BNF showed statically significant difference only during vulsalva maneuver and statically significance difference according to PVR and presence of cystocele. No statically significant difference between both groups according to BWT.

According to retrovesical (β) angle, Keshavarz et al. [10] compared results between 44 cases, and 44 controls showed statically significant variance among controls and cases for β angle during rest & vulsalva maneuver that the angle with the Valsalva maneuver (144.22° ± 19.63° vs 111.81° ± 24.47°) among the control & case groups. Additionally, the β angle without the Valsalva maneuver was elevated in the case group (120.17°± 25.16°) than the control group (112.35° ± 23.10°) which is like our results with cut off point for β angle was127° with the Valsalva maneuver, that showed 89% sensitivity and 79% specificity. However, they used higher cut off results compared to our study in β angle at rest 115° that showed sensitivity only 60% and specificity 80% compared to our study we used cut off value 110° with 76.19% specificity 90.48%.

In research by Al-Saadi [15], TPUS outcomes of thirty females with SUI (validated through urodynamic tests) were compared to those of thirty healthy females. A significantly elevated β angle in the case group compared to the control group was also described at rest (mean of 125.27° vs 107.53°) & straining (mean of 153.57° vs 123.87°). Also, with higher cut off results compared to our study in β angle at rest 119° that showed sensitivity only 63.3% and specificity 60% and 141.5° that showed sensitivity only 73.3% and specificity 80%. However, Dong et al study that performed transperineal ultrasound on empty bladder showed that cut-off of BND at 10.8 ml provided 68%, specificity and 71% sensitivity, the mean β angle at rest was 118.8° ± 16.1° and 133.5° ± 16.1°at vulsalva in cases compared to 122.5° ± 14.8° at rest and 143.4° ± 15.7° at vulsalva in controls with statically significant difference only at vulsalva. [16]

Different studies tried to classify cases according to severity and compared between these groups, El lithy classified 52 patients of SUI into Thirty-six instances were classified as light, twelve as moderate, and merely four as severe, utilizing Valsalva leak point pressure in the urodynamic study showed statically significant difference in β measurements during rest and straining and BND while compared mild to severe cases, while comparing among moderate & mild cases, there was statically significant variance only during straining and in BND measurement, however, no statically significant difference in any measurements when comparing moderate to severe cases. [17]

However, Wen et al that performed TPUS on empty bladder show no statically significant difference between cases and controls it may be due to different technique used. [19] Also, Keshavarz et al. showed that BNF with the Valsalva maneuver was documented in eleven females, involving one case in the control group & ten women in the case group but without any significant variance among the groups [10], so we need more studies to evaluate BNF as a diagnostic measure for SUI.

The sonographic funneling symptom is defined as the opening of the proximal urethra on exertion. Our results, similar to the results obtained by Pietrus et al. obviously show the existence of the funneling sign in females with SUI. The funneling sign most probable indicates internal urethral sphincter insufficiency. This pathology may happen in isolation or overlap with other causes of UI, like the hypermobility of the bladder neck. [18]

Li et al. another study showed statically significant variance among cases and controls in comparison between measurements of in β angle and BND, then they classified 87 cases according to Ingelman-Sundberg procedure one of the earliest attempts to classify female stress urinary incontinence [20]. It is based mainly on urethral sphincter function and bladder neck position. based on clinical symptoms into 68 moderate cases and 19 severe patients showed that no statically significant difference between both groups in β angle and BND however it may be due to detecting US parameters on empty bladder (less than 50 ml), no mild cases involved in comparison. [21]

Conclusion: Measuring retrovesical (β) angle and bladder neck descent by TPUS can be useful as a diagnostic maneuver for SUI and can replace urodynamic test as a simple noninvasive and cost

effective. However, more studies with larger sample size were needed to detect standardized cut off point, accurate urine volume and adequate straining time for diagnosis and comparing between transperineal and transvaginal ultrasound for best diagnostic results.

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