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Diagnostic Performance of Dynamic Transperineal Ultrasound in Early Postpartum Stress Urinary Incontinence: A Prospective Case – Control Study

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Abstract

Introduction: Stress urinary incontinence (SUI) is a common postpartum pelvic floor disorder associated with pregnancy- and childbirth-related alterations of pelvic floor support structures. Dynamic transperineal ultrasound provides a non-invasive imaging tool for assessing pelvic floor dysfunction.

Objective: To evaluate the diagnostic performance of dynamic transperineal ultrasound using sonographic parameters in early postpartum SUI and to identify associated clinical risk factors.

Materials and Methods: A prospective case–control study was conducted on 110 postpartum women (6–12 weeks), including 55 women with clinically diagnosed SUI and 55 continent controls. SUI was diagnosed on the basis of symptoms and clinical history, with a validated urinary-incontinence questionnaire also used. Dynamic transperineal ultrasound was performed using a Samsung RS80A system with a 3.5–5 MHz curvilinear transducer. Bladder neck descent (BND), urethral funneling angle, urethral rotation angle, retrovesical angle, and bilateral puborectalis muscle thickness were assessed at rest and during maximum Valsalva; Valsalva measurements were compared between groups. Multivariable logistic regression and ROC curve analysis were used.

Results: Maternal age (OR = 1.24, p = 0.011), parity (OR = 2.01, p = 0.031), and vaginal delivery (OR = 3.34, p = 0.026) were independently associated with SUI. Mean bladder neck descent was significantly higher in cases compared with controls (18.43 ± 2.91 mm vs. 15.42 ± 3.24 mm, p < 0.001). Similarly, mean urethral funneling angle was greater in symptomatic women

(20.81 ± 4.28° vs. 16.73 ± 5.07°, p < 0.001). ROC analysis demonstrated moderate discriminatory ability for BND with a cut-off value >17.2 mm (AUC = 0.756, sensitivity 78.2%, specificity 70.9%), while a funneling angle >21.5° also showed moderate discriminatory ability (AUC = 0.730).

Conclusion: Dynamic transperineal ultrasound demonstrated significant differences in bladder neck descent and urethral funneling between women with early postpartum SUI and continent controls. These sonographic parameters were independently associated with SUI and may provide useful objective markers to complement clinical assessment.

Keywords: Stress Urinary Incontinence, Transperineal Ultrasound, Postpartum, Bladder Neck Descent, Pelvic Floor Dysfunction.

Introduction

Stress urinary incontinence (SUI) is defined by the International Continence Society (ICS) and International Urogynecological Association (IUGA) as the involuntary leakage of urine during physical exertion, coughing, sneezing, or other activities that increase intra-abdominal pressure.[1,13] It is particularly common during the postpartum period owing to pregnancy- and childbirth-related alterations of the pelvic floor and remains one of the leading causes of postpartum pelvic floor dysfunction worldwide.[2,8,9,14] Although many women experience spontaneous improvement after delivery, a substantial proportion continue to have persistent symptoms that adversely affect quality of life, physical activity, psychological well-being, sexual function, and social participation.[2,14] Early recognition of women at risk is therefore essential to facilitate timely intervention and prevent long-term pelvic floor morbidity.

Pregnancy and vaginal childbirth produce profound anatomical and functional changes within the pelvic floor. Hormonal influences, including the effects of relaxin and progesterone, promote connective tissue remodelling, while mechanical stretching during pregnancy and vaginal delivery may result in levator ani muscle injury, disruption of the endopelvic fascia and pubourethral ligaments, and pudendal nerve damage.[3,4,10] These structural and neuromuscular alterations contribute to bladder neck hypermobility, urethral hypermobility, and impaired urethral closure mechanisms, ultimately predisposing women to postpartum SUI.[3,4,11] The risk is further increased by advancing maternal age, multiparity, vaginal delivery, prolonged second stage of labour, instrumental delivery, fetal macrosomia, and obesity.[2,8–10,14]

The early postpartum period, particularly between 6 and 12 weeks after delivery, represents a critical phase during which pregnancy-related pelvic floor changes become clinically apparent. Although the diagnosis of SUI is primarily based on clinical history and physical examination, objective assessment is often necessary to evaluate the underlying anatomical abnormalities, determine the severity of pelvic floor dysfunction, and guide appropriate management. Urodynamic testing may provide functional assessment in selected patients; however, it is invasive, time-consuming and is not routinely required for the initial evaluation of uncomplicated postpartum SUI. Consequently, there is increasing interest in imaging techniques that provide objective anatomical and functional evaluation while remaining patient-friendly.

Dynamic transperineal ultrasound has emerged as a simple, non-invasive, and radiation-free imaging modality for the assessment of pelvic floor disorders. It enables real-time visualization of pelvic floor anatomy during rest and Valsalva manoeuvre, allowing objective evaluation of bladder neck descent, urethral mobility,

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urethral funneling, levator ani integrity, and other pelvic floor parameters.[5–7] Compared with urodynamic testing, transperineal ultrasound is well tolerated, inexpensive, widely available, and readily incorporated into routine clinical practice, making it particularly attractive for postpartum assessment.

Recent studies have demonstrated that dynamic transperineal ultrasound possesses good diagnostic accuracy for identifying postpartum pelvic floor dysfunction and may serve as a valuable adjunct to clinical evaluation.[15–17] Furthermore, predictive models integrating ultrasound findings with clinical risk factors have shown promising results for the early identification of women at risk of persistent postpartum SUI.[16,17] Nevertheless, evidence from the Indian population remains limited, and there is no universally accepted sonographic threshold for several dynamic pelvic floor parameters. Variations in ethnicity, obstetric practices, postpartum assessment protocols, and imaging techniques further highlight the need for region-specific evidence to improve the applicability of ultrasound findings in clinical practice.

Therefore, the present study aimed to evaluate the role of dynamic transperineal ultrasound in postpartum women with stress urinary incontinence by comparing sonographic pelvic floor parameters between symptomatic and continent women, identifying clinical and sonographic factors independently associated with SUI, and determining diagnostic cut-off values for ultrasound parameters in the early postpartum period.

Materials and Methods

Study Design and Population

The study received approval from the Institutional Ethics Committee of GSVM Medical College, Kanpur, Uttar Pradesh (IEC approval number: EC/BMHR/2024/188). Written informed consent was obtained from all participants.

This prospective case–control study was conducted over a period of 18 months (August 2024 to December 2025) in the Department of Radiodiagnosis in collaboration with the Department of Obstetrics and Gynecology at GSVM Medical College, Kanpur, Uttar Pradesh, India. A total of 110 postpartum women, evaluated between 6 and 12 weeks following delivery, were included. Participants were recruited from postpartum and gynecology clinical services and radiology referrals. The cohort comprised 55 women with clinically diagnosed SUI and 55 continent postpartum controls. SUI was diagnosed on the basis of symptoms and clinical history by the obstetric/gynecology clinical team; the validated international consultation on incontinence questionnaire-Urinary incontinence short form (ICIQ-UI SF) was also used. A cough stress test was not performed. Controls had no symptoms of urinary incontinence. Inclusion criteria comprised postpartum women aged ≥18 years who had undergone either vaginal or cesarean delivery and were willing to provide informed consent. Patients with a history of urinary incontinence prior to pregnancy, previous pelvic or urogynecological surgery (excluding cesarean section), neurological disorders affecting bladder function, chronic conditions impacting continence (e.g., chronic cough, diabetic neuropathy), or mixed/urge urinary incontinence were excluded.

Clinical Assessment

A detailed clinical history was obtained for all participants, documenting maternal age, parity, mode of delivery, duration of labor, and obstetric history. Stress urinary incontinence was clinically defined as involuntary urinary leakage during activities that increase intra-abdominal pressure, such as coughing, sneezing, or physical exertion. Clinical diagnosis was based on

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symptoms and history; the validated international consultation on incontinence Questionnaire-Urinary incontinence short form (ICIQ-UI SF) was also used. A cough stress test was not performed.

Ultrasound Technique and Dynamic Assessment

Dynamic transperineal ultrasound was performed using a Samsung RS80A ultrasound system equipped with a 3.5–5 MHz curvilinear transducer. Patients were examined in the supine position with the hips flexed and slightly abducted. The transducer was placed on the perineum in the midsagittal plane with minimal pressure to avoid restricting pelvic floor movement. A comfortably filled bladder was maintained to optimize visualization. Images were acquired at rest and during maximum Valsalva manoeuvre. All examinations were performed by the study radiologist, who was blinded to the clinical status of the participants.

Each participant performed at least three Valsalva attempts, and the maximum value obtained across the three attempts was used for analysis. The values reported for between-group comparison were obtained during maximum Valsalva. The evaluated sonographic parameters included bladder neck descent (BND), defined as the vertical displacement of the bladder neck from rest to maximum Valsalva relative to the inferior margin of the pubic symphysis; urethral funneling angle, measured as the angle of opening of the proximal urethra during Valsalva; urethral rotation angle, representing the change in the urethral axis between rest and strain; retrovesical angle (RVA), measuring the angle between the proximal urethra and bladder base during Valsalva; and puborectalis muscle thickness (PRMT), measured bilaterally at the anorectal junction during Valsalva.



Figure 1: Samsung RS80A USG machine

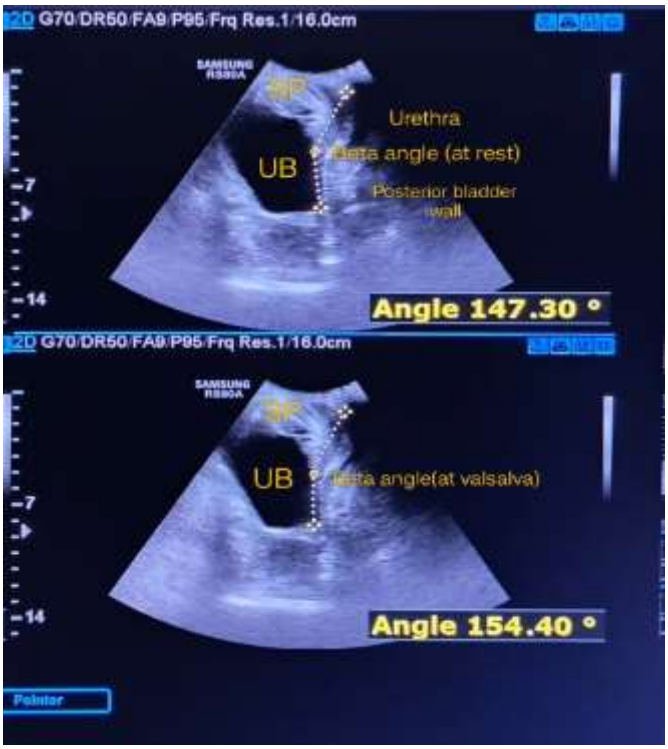


Figure 2: USG scan shows Transperineal measurement of retrovesical angle

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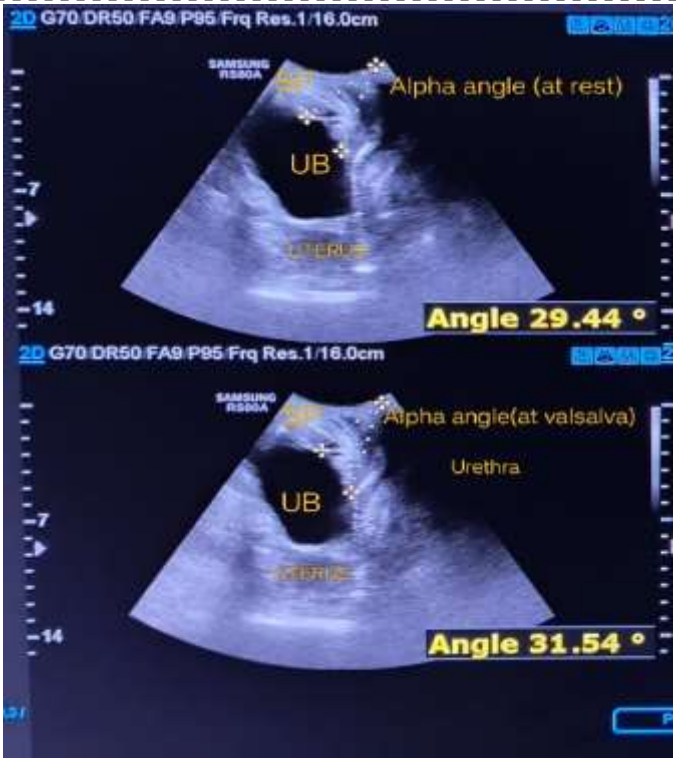


Figure 3: USG scan shows transperineal measurement of urethral rotational angle

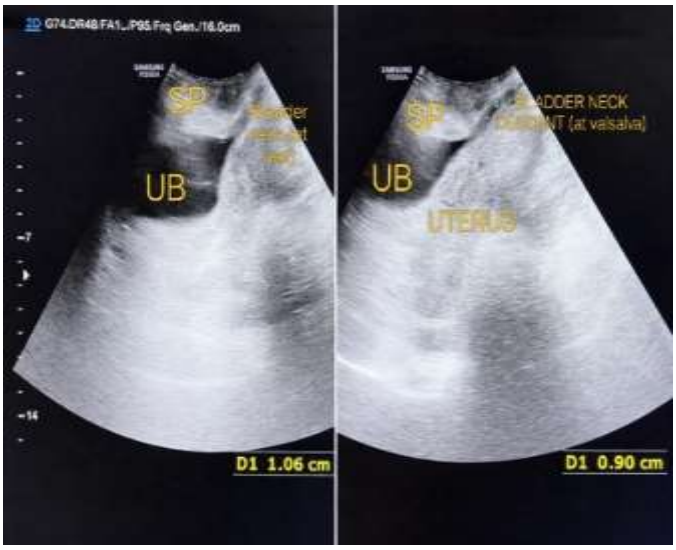


Figure 4: USG scan shows Transperineal measurement of bladder neck descent



Figure 5: USG scan shows Transperineal measurement of urethral funneling angle

Statistical Analysis

Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared using the independent Student's t-test. Categorical variables were analyzed using the Chi-square test. Multivariable logistic regression was used to identify clinical and sonographic factors independently associated with SUI; variables significant at $p<0.10$ on univariate analysis (age, parity, mode of delivery, BND, and urethral funneling angle) were entered into the model, with cesarean delivery as the reference category for mode of delivery. Receiver operating characteristic (ROC) curve analysis was performed to determine discriminatory ability and optimal diagnostic cut-off values, with the optimal thresholds selected using the Youden index. The p-value of <0.05 was considered statistically significant.

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Results and Discussion

Baseline Clinical Characteristics

Table 1: Comparison of clinical parameters between stress urinary incontinence cases and controls

Parameter	Cases (Mean ± SD)	Controls (Mean ± SD)	Test Used	p-value
Age (years)	28.93 ± 3.65	25.35 ± 3.55	Independent t-test	<0.001
Parity	2.62 ± 0.89	1.87 ± 0.86	Independent t-test	<0.001
Mode of Delivery (Vaginal %)	65.5%	38.2%	Chi-square test	0.008

The mean maternal age was significantly higher in the SUI group compared to the asymptomatic controls (28.93 ± 3.65 years vs. 25.35 ± 3.55 years, $p < 0.001$). Parity was also significantly elevated among the symptomatic cases (2.62 ± 0.89) compared to the controls (1.87 ± 0.86, $p < 0.001$). Furthermore, vaginal delivery was considerably more common in symptomatic women (65.5%) compared to continent controls (38.2%), demonstrating a statistically significant association with the development of SUI (chi square = 7.14, p = 0.008)

Pelvic Floor Ultrasound Findings

Table 2: Comparison of pelvic floor ultrasound measurements between stress urinary incontinence cases and controls

Parameter	Cases (Mean ± SD)	Controls (Mean ± SD)	Test Used	p-value
Bladder Neck Descent (mm)	18.43 ± 2.91	15.42 ± 3.24	Independent t-test	<0.001
Funnel Angle (°)	20.81 ± 4.28	16.73 ± 5.07	Independent t-test	<0.001
Urethral Rotation Angle(°)	30.05 ± 1.81	29.48 ± 1.76	Independent t-test	0.096
Retrovesical Angle (°)	150.39 ± 3.48	149.49 ± 2.84	Independent t-test	0.137
Right Puborectalis Thickness (mm)	1.00 ± 0.03	1.01 ± 0.02	Independent t-test	0.263
Left Puborectalis Thickness (mm)	1.00 ± 0.03	1.00 ± 0.03	Independent t-test	0.739

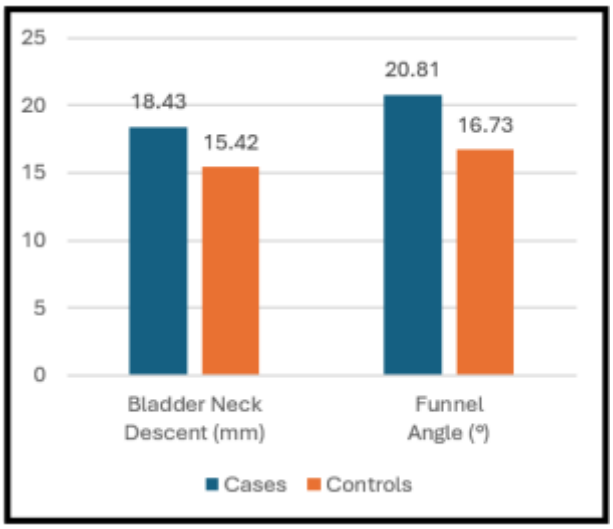


Figure 6: Comparison of bladder neck descent and urethral funneling angle between cases and controls

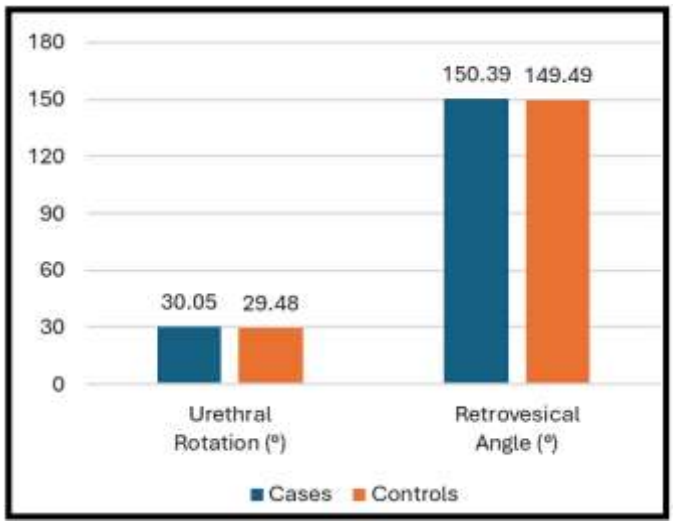


Figure 7: Comparison of urethral rotational angle and retrovesical angle between cases and controls

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Bladder neck descent and urethral funneling angle were significantly greater in women with SUI than in continent controls (18.43 ± 2.91 mm vs. 15.42 ± 3.24 mm and 20.81 ± 4.28° vs. 16.73 ± 5.07°, respectively; both $p < 0.001$). In contrast, urethral rotation angle and retrovesical angles did not differ significantly between the two groups ($p = 0.096$ and $p = 0.137$, respectively). Similarly, no significant differences were observed in right or left puborectalis muscle thickness ($p = 0.263$ and $p = 0.739$, respectively). These findings suggest that bladder neck mobility and urethral funneling were the principal sonographic parameters associated with SUI in this cohort.

Multivariable Predictors of Stress Urinary Incontinence

Table 3: Multivariable logistic regression analysis of independent predictors of stress urinary incontinence

Variable	Adjusted Odds Ratio	95% CI	p-value
Age	1.24	1.05–1.46	0.011
Parity	2.01	1.06–3.77	0.031
Mode of Delivery (Vaginal)	3.34	1.15–9.65	0.026
Bladder Neck Descent	1.29	1.08–1.55	0.005
Funnel Angle	1.14	1.01–1.29	0.032

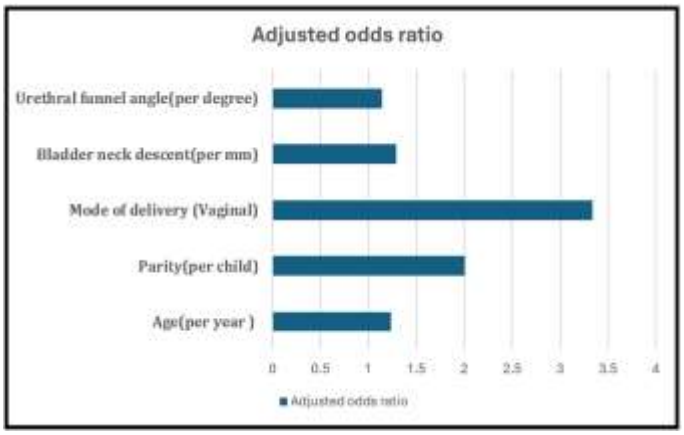


Figure 8: Bar chart showing multivariable predictors of stress urinary incontinence

Multivariable logistic regression analysis identified several independent predictors of stress urinary incontinence. Maternal age (OR = 1.24, $p = 0.011$) and parity (OR = 2.01, $p = 0.031$) were found to be significant clinical risk factors, indicating that increasing age and higher parity were associated with a greater likelihood of developing SUI. Vaginal delivery also demonstrated a strong association (OR = 3.34, $p = 0.026$), highlighting its role as a major contributing factor to pelvic floor dysfunction. Among the sonographic parameters, bladder neck descent emerged as the strongest independent predictor (OR = 1.29 per 1 mm increase, $p = 0.005$), followed by urethral funneling angle (OR = 1.14 per 1° increase, $p = 0.032$), reinforcing the importance of dynamic pelvic floor assessment. Odds ratios for age and bladder neck descent are expressed per 1-year and per 1 mm increase respectively, for parity per additional child, and for funnel angle per 1° increase.

ROC Curve Analysis

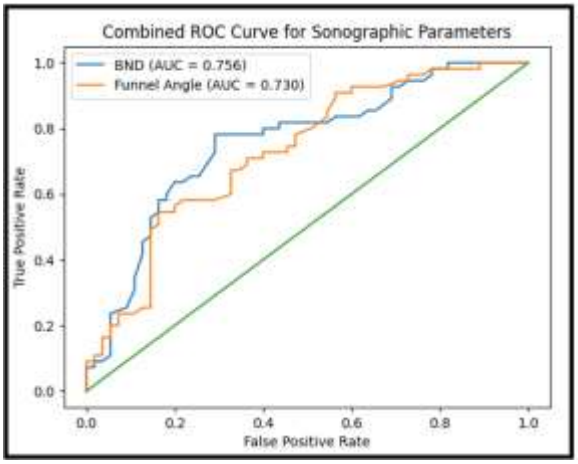


Figure 9: Receiver Operating Characteristic (ROC) curve demonstrating the diagnostic performance of Bladder

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Neck Descent (BND) and Urethral Funneling Angle in identifying stress urinary incontinence among postpartum women.

Receiver operating characteristic (ROC) analysis demonstrated that bladder neck descent had the greatest discriminatory ability among the evaluated ultrasound parameters, with an AUC of 0.756. A cut-off value of >17.2 mm yielded a sensitivity of 78.2% and a specificity of 70.9% for identifying SUI. The urethral funneling angle also demonstrated moderate discriminatory ability, with an AUC of 0.730 at a cut-off of >21.5°, yielding a sensitivity of 54.5% and a specificity of 83.6%.

Discussion

The present prospective case–control study demonstrates that dynamic transperineal ultrasound is a valuable, non-invasive imaging modality for evaluating postpartum stress urinary incontinence (SUI). Women with SUI exhibited significantly greater bladder neck descent and urethral funneling than continent controls. Furthermore, maternal age, parity, vaginal delivery, bladder neck descent, and urethral funneling were identified as independent predictors of SUI. Among all evaluated sonographic parameters, bladder neck descent showed the highest diagnostic performance, highlighting its potential as an objective imaging biomarker for postpartum pelvic floor dysfunction. These findings reinforce the growing role of dynamic transperineal ultrasound as a reliable imaging tool for objective assessment of pelvic floor anatomy and function in postpartum women.

Maternal age, parity, and vaginal delivery emerged as significant independent clinical predictors of postpartum SUI in the present study. Each one-year increase in maternal age was associated with a 24% increase in the odds of developing SUI (OR 1.24; p = 0.011), while each additional child was associated with approximately two-fold higher odds of SUI (OR 2.01; p = 0.031). Vaginal delivery remained the strongest clinical predictor, increasing the likelihood of SUI by more than threefold (OR 3.34; p = 0.026). These observations are in agreement with the landmark studies by Viktrup et al. and Rortveit et al., who demonstrated that pregnancy, increasing parity, and vaginal childbirth substantially increase the risk of postpartum urinary incontinence by causing cumulative injury to the pelvic floor musculature, connective tissues, and pudendal nerve.[8,9] More recently, the systematic review and meta-analysis by Dai et al. confirmed that maternal age, vaginal delivery, and multiparity remain among the strongest risk factors for postpartum urinary incontinence across different populations.[14] Similarly, Feng et al. reported comparable associations in women evaluated using dynamic transperineal ultrasound, emphasizing the combined influence of obstetric factors and pelvic floor morphological changes on postpartum SUI.[15,16] Collectively, these findings support the concept that postpartum SUI is multifactorial, resulting from both obstetric risk factors and structural pelvic floor dysfunction.

Bladder neck descent was the most important sonographic parameter identified in the present study. Women with SUI demonstrated significantly greater bladder neck descent than continent controls (18.43 ± 2.91 mm versus 15.42 ± 3.24 mm, p < 0.001). Multivariable logistic regression analysis further established bladder neck descent as an independent predictor of SUI (OR 1.29; p = 0.005). ROC curve analysis demonstrated moderate discriminatory ability, with an area under the curve (AUC) of 0.756. A threshold value of >17.2 mm yielded a sensitivity of 78.2% and a specificity of 70.9% for identifying postpartum women with SUI. The diagnostic significance

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of bladder neck mobility has been extensively described by Dietz et al., who identified excessive bladder neck descent as one of the most reliable sonographic indicators of urethral support failure and stress urinary incontinence.[5–7] Their work established dynamic transperineal ultrasound as an effective method for assessing pelvic floor dysfunction by providing objective measurements of bladder neck mobility during Valsalva manoeuvre. More recently, Feng et al. reported significantly greater bladder neck mobility in postpartum women with SUI and highlighted its usefulness in identifying women at risk of persistent pelvic floor dysfunction.[15,16] Although the reported cut-off values vary across different studies, these differences are likely attributable to variations in bladder filling status, postpartum interval, patient characteristics, and ultrasound measurement techniques. Nevertheless, the cut-off value identified in the present study (>17.2 mm) lies within the range reported in previous literature and further supports the reproducibility and clinical applicability of dynamic transperineal ultrasound in postpartum pelvic floor assessment.

Urethral funneling also demonstrated a significant association with postpartum stress urinary incontinence in the present study. Women with SUI exhibited a significantly greater mean funneling angle than continent controls (20.81 ± 4.28° versus 16.73 ± 5.07°, $p < 0.001$). Multivariable logistic regression identified urethral funneling as an independent predictor of SUI (OR 1.14; $p = 0.032$). ROC analysis demonstrated moderate discriminatory ability, with an area under the curve (AUC) of 0.730. A cut-off value of >21.5° yielded a sensitivity of 54.5% and a specificity of 83.6%. Although its sensitivity was lower than that of bladder neck descent, the relatively high specificity suggests that urethral funneling is a valuable complementary imaging marker, particularly for identifying women with significant urethral sphincter incompetence. Feng et al. similarly reported a significant association between urethral funneling and postpartum SUI and emphasized that combining urethral funneling with bladder neck mobility improves the diagnostic performance of transperineal ultrasound.[15,16] Likewise, Liu et al. demonstrated that integrating ultrasound-derived pelvic floor parameters with established clinical risk factors provides superior prediction of postpartum SUI compared with any individual sonographic measurement alone.[17] These findings support a multiparametric ultrasound approach for comprehensive evaluation of postpartum pelvic floor dysfunction.

In contrast, urethral rotation angle, retrovesical angle, and puborectalis muscle thickness did not differ significantly between women with and without SUI in the present study. Similar observations have been reported by Dietz et al., who noted that although these parameters may reflect pelvic floor biomechanics, they demonstrate greater physiological variability and possess lower diagnostic accuracy than bladder neck mobility for detecting stress urinary incontinence.[6,7] More recently, Feng et al. also observed that bladder neck descent remained the most robust sonographic predictor of postpartum SUI, whereas secondary ultrasound parameters contributed relatively little additional diagnostic value.[15] These findings suggest that bladder neck descent and urethral funneling should be considered the principal imaging markers during routine transperineal ultrasound evaluation of postpartum women suspected of having stress urinary incontinence.

The findings of the present study have important clinical implications. Dynamic transperineal ultrasound is inexpensive, non-invasive, radiation-free, widely available, and well tolerated by postpartum women,

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making it particularly suitable for routine clinical practice. Unlike urodynamic studies, which are invasive, time-consuming, and not universally available, transperineal ultrasound provides objective real-time assessment of pelvic floor anatomy and functional changes during the Valsalva manoeuvre. The recent ICS/IUGA joint report by Doumouchtsis et al. highlighted the increasing role of imaging in the standardized evaluation of obstetric pelvic floor disorders and emphasized the importance of objective imaging biomarkers in guiding diagnosis and management.[13] In the present study, the proposed cut-off values for bladder neck descent and urethral funneling may assist radiologists and urogynecologists in identifying women at increased risk of postpartum SUI, facilitating early initiation of pelvic floor muscle training, behavioural modification, and appropriate follow-up. In resource-limited healthcare settings, where access to specialized urodynamic evaluation may be restricted, dynamic transperineal ultrasound offers a practical, accessible, and cost-effective alternative for the objective assessment of postpartum pelvic floor dysfunction. [12,16]

The present study has several strengths. It prospectively evaluated a well-defined cohort of postpartum women using a standardized dynamic transperineal ultrasound protocol, ensuring uniform acquisition and assessment of pelvic floor parameters. The inclusion of a continent control group enabled comparisons between symptomatic and asymptomatic postpartum women. Furthermore, the use of multivariable logistic regression enabled identification of independent clinical and sonographic predictors of postpartum SUI, while ROC curve analysis facilitated the determination of clinically relevant diagnostic cut-off values. These methodological strengths improve the clinical applicability of the findings and support the role of dynamic transperineal ultrasound as an objective imaging modality for postpartum pelvic floor evaluation. Similar standardized ultrasound protocols have been advocated by Dietz et al. and the recent ICS/IUGA recommendations by Doumouchtsis et al., emphasizing the importance of reproducible imaging techniques in the assessment of pelvic floor disorders. [6,13]

Future multicentre prospective studies involving larger and ethnically diverse populations are warranted to validate the proposed sonographic cut-off values and establish standardized ultrasound criteria for the evaluation of postpartum stress urinary incontinence. Longitudinal follow-up studies are needed to determine whether early postpartum ultrasound abnormalities predict persistent urinary incontinence and long-term pelvic floor dysfunction. Furthermore, integration of three-dimensional transperineal ultrasound, pelvic floor elastography, and artificial intelligence-based predictive models, as explored in recent studies by Feng et al. and Liu et al., may further enhance the diagnostic accuracy and clinical utility of pelvic floor imaging. [16–19] Such advances could facilitate individualized risk stratification, early therapeutic intervention, and improved long-term outcomes in women with postpartum stress urinary incontinence.

Limitations

While the findings are robust, this study is subject to certain limitations. It was conducted at a single tertiary care center with a relatively moderate sample size. Additionally, the lack of interobserver variability assessment and direct correlation with invasive urodynamic studies represent limitations in the methodological scope. Additionally, SUI diagnosis was based on symptoms, clinical history, and a validated questionnaire rather than objective confirmation such as a cough stress test or urodynamic testing, which may have introduced some misclassification. Finally, the absence

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of longitudinal, long-term follow-up precludes the evaluation of symptom persistence or spontaneous resolution beyond the early postpartum window.

Conclusion

Dynamic transperineal ultrasound demonstrated significant differences in bladder neck descent and urethral funneling between women with early postpartum SUI and continent controls. BND and urethral funneling were independently associated with SUI and demonstrated moderate discriminatory ability, with thresholds of >17.2 mm and >21.5°, respectively, in this study cohort. These findings suggest that dynamic transperineal ultrasound may provide a useful non-invasive adjunct to clinical assessment of early postpartum SUI. External validation in larger, multicentre cohorts is required before these thresholds can be generalized to routine clinical practice.

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