Literature Review

Pelvic Floor Ultrasound for the Evaluation of Urethral Mobility in Women with Stress Urinary Incontinence: A Literature Review

Sania Utari,[1] Edy Fakhrizal[2]
[1]Resident of Departement Obstetrics & Gynecology, Faculty of Medicine Universitas Riau, Pekanbaru - Indonesia
[2]Division of Urogynecology and Aesthetic Reconstructive Pelvic Floor Surgery, Departement Obstetrics & Gynecology, Faculty of Medicine Universitas Riaul, Pekanbaru – Indonesia
Corresponding: Edy Fakhrizal Email: dr.edyfakhrizal@lecturer.unri.ac.id
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Abstract
Introduction: Stress urinary incontinence (SUI) is the most common urinary incontinence in women, mainly associated with urethral hypermobility and reduced intrinsic sphincter function. Transperineal pelvic floor ultrasound (PFU) is a minimally invasive, low-cost imaging method that quantifies urethral mobility through bladder neck descent (BND), urethral rotation angle (URA), and retrovesical angle (RVA).
Objectives: To summarize available evidence on PFU diagnostic performance and its potential clinical role in identifying urethral hypermobility in women with SUI.
Methods: This literature review focuses on transperineal PFU as a noninvasive approach to assess urethral hypermobility, primarily using BND, URA, and RVA measurements.
Results: Multiple studies report PFU provides reproducible measurements with acceptable sensitivity and specificity for diagnosing SUI. Although cutoff values for URA and RVA vary depending on study quality and methodology, these parameters consistently serve as key indicators of urethral hypermobility. Compared with standard invasive techniques, PFU improves patient comfort, offers real-time dynamic visualization, and allows greater clinical flexibility.
Conclusion: PFU is a promising adjunct for diagnosing passive urethral hypermobility and may reduce reliance on invasive tests while maintaining accuracy. Larger studies are needed to standardize protocols and validate cutoff values across diverse populations.

Keywords: Pelvic floor ultrasound; urethral mobility; bladder neck descent; urethral rotation angle; stress urinary incontinence

Ultrasonografi Dasar Panggul sebagai Alat Diagnostik untuk Mengevaluasi Hipermobilitas Uretra pada Wanita dengan Inkontinensia Urin Stres: Sebuah Tinjauan Pustaka

Abstrak
Pendahuluan: Stress urinary incontinence (SUI) merupakan jenis inkontinensia urin yang paling sering pada perempuan, terutama berkaitan dengan hipermobilitas uretra dan penurunan fungsi sfingter intrinsik. Ultrasonografi dasar panggul (PFU) transperineal adalah metode pencitraan yang minim invasif dan berbiaya rendah untuk menilai mobilitas uretra secara kuantitatif melalui penurunan leher kandung kemih (BND), sudut rotasi uretra (URA), dan sudut retrovesikal (RVA).
Tujuan: Merangkum bukti yang tersedia mengenai kinerja diagnostik PFU serta potensi perannya dalam praktik klinis untuk mengidentifikasi hipermobilitas uretra pada perempuan dengan SUI.
Metode: Tinjauan pustaka ini berfokus pada PFU transperineal sebagai metode noninvasif untuk menilai hipermobilitas uretra, dengan parameter utama berupa BND, URA, dan RVA.
Hasil: Berbagai studi melaporkan bahwa PFU menghasilkan pengukuran yang reprodusibel dengan sensitivitas dan spesifisitas yang dapat diterima untuk diagnosis SUI. Meskipun nilai ambang URA dan RVA bervariasi bergantung pada kualitas dan metodologi studi, kedua parameter tersebut secara konsisten menjadi indikator penting hipermobilitas uretra. Dibandingkan teknik invasif standar, PFU meningkatkan kenyamanan pasien, menyediakan visualisasi dinamis secara real-time, dan menawarkan fleksibilitas klinis yang lebih tinggi.
Kesimpulan: PFU merupakan pemeriksaan tambahan yang menjanjikan untuk mendiagnosis hipermobilitas uretra pasif dan berpotensi mengurangi ketergantungan pada tes invasif tanpa menurunkan akurasi. Namun, diperlukan studi berskala lebih besar untuk menstandardisasi protokol dan memvalidasi nilai ambang pada berbagai populasi.

Kata kunci: Bladder neck descent; inkontinensia urin stress; mobilitas uretra; sudut rotasi uretra; Ultrasonografi dasar panggul

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Introduction

Stress urinary incontinence (SUI) is a common pelvic floor disorder with an estimated prevalence rate among women worldwide of 10–70%, having a serious effect on health related quality of life. The major underlying mechanism is urethral hypermobility and loss of pelvic floor support. Therefore, accurate assessment of urethral mobility is essential for establishing an appropriate diagnosis and developing an effective treatment plan.[1]

Urethral hypermobility has traditionally been evaluated by the Q-tip test and pad tests, but both have flaws. The pad test is cumbersome and invasive, whereas the Q-tip test is less sensitive. Hence, there is a need for a more reliable and patient friendly reproducible diagnostic method.[2]

Over the last few decades, particularly Pelvic Floor Ultrasound (PFU) had more wide ranging applications in obstetrics and gynecology. Its use in urogynecology, especially for assessing urethral hypermobility, is also increasingly being recognized. Transperineal ultrasound enables dynamic, real-time visualization of the bladder neck and urethra, especially during functional maneuvers such as the Valsalva maneuver.[3] Commonly evaluated parameters are bladder neck descent (BND), urethral rotation angle (URA) and retrovesical angle (RVA). Different cut off values for urethral hypermobility of URA and RVA have been reported in previous animal studies, but BND showed the highest diagnostic sensitivity and specificity for SUI.[2,3]

Urethral hypermobility has traditionally been assessed using the Q-tip test and the pad test; however, both methods have notable limitations. The pad test can be time consuming and uncomfortable for patients, while the Q-tip test is invasive and may have limited sensitivity. Therefore, there is a need for a more reliable, patient friendly, and reproducible diagnostic approach.[4]

The aim of this literature review is to provide an overview of existing data on pelvic floor ultrasound in urethral mobility assessment focusing on its diagnostic parameters (BND, URA and RVA), accuracy regarding conventional investigations and the non invasive role for detection of urethral hypermobility in clinical practice.

Method

Hereby we performed this literature review to assess the value of pelvic floor ultrasound (PFU) in the assessment of urethral mobility both in and outside women suffering of stress urinary incontinence (SUI). A systematic search was conducted using PubMed, Scopus, ScienceDirect and Google Scholar. Search strategyKeywords such as “pelvic floor ultrasound”, “transperineal ultrasound”, “urethral mobility”, “bladder neck descent”, “urethral rotation angle” and “retrovesical angle” and also by using the terms ‘stress urinary incontinence’. Only published, English language articles between 2015 and 2024 that contained information on studies examining ways to treat adult females diagnosed with SUI were included.

Therefore, relevant literature inclusion & identification were original research articles or systematic reviews on PFU parameters (bladder neck descent [BND], urethral rotation angle ([URA), or retrovesical angle (RVA) dan comparisons of PFU VS traditional diagnostic tests. We excluded case report, abstracts without full text availability and non English publications from the review. Relevant data on study design, sample size, ultrasound technique, diagnostic parameters and relevant outcomes were extracted and narratively summarized to demonstrate the diagnostic accuracy, advantages and limitations of PFU.

Result

Stress urinary incontinence (SUI) is defined as involuntary loss of urine with exertion coughingsneezing laughing straining physical exercise when the bladder pressure surpasses maximal urethral closure pressure.[2] Patients often refer to this kind of leakage as "dripping," "leaking" or "flooding." IntroductionStress urinary incontinence (SUI) is the most common subtype of urinary incontinence, with a significant negative impact on women quality of life at both the physical and psychological levels.[5]

SUI is categorized into three types according to the Ingelmann Sundberg system. Type I comprises mild urethral hypermobility associated with normal urethrovesical angle leading to leakage during high impact activities, such as coughing or sneezing. Type II is characterized by significant urethral hypermobility, resulting in urine leakage during mild physical activities due to weakened pelvic floor support, commonly associated with childbirth or aging. On the other hand, type III represents intrinsic sphincter deficiency, causing leakage without increased abdominal pressure, typically after nerve injury or pelvic surgeries. Avi agrees and states that urinary incontinence as a whole can be divided into 4 categories: stress, urgency, mixed (SUI + UUI), overflow, and functional with SUI being primary related to sphincter insufficiency or pelvic floor weakness.[3]

Stress urinary incontinence (SUI) continues to have a global prevalence range of 10–70% among women, depending on the population and methodology employed by different epidemiological studies. Prevalence was 46% in the US from 2017 to 2020, and was 18.9% among women >20 years in China. In Indonesia 20.3% of women post partum had urinary incontinence, 8.8% diagnosed as SUI. Urinary incontinence becomes more common with advancing age, particularly after menopause, and can occur in up to 77% of elderly residents living in nursing homes. Although BO is highly prevalent, only approximately 60% of affected individuals receive treatment, leading to significant economic burden.[6]

Stress urinary incontinence (SUI) has the etiology of pelvic floor muscle excessive weakening and urethral sphincter dysfunction, leading to unopposed closure of the urethra by abdomen pressure. The process of urethral atrophy is suffered due to the decline in estrogen levels post menopause; hence after menopause urinary incontinence can worsen. The predominant risk factor is delivery via vaginal route, which may injure pelvic floor muscle and nerves during prolonged labor or instrument aided delivery. Moreover, obesity increases intra abdominal pressure, the positive family history and smoking through chronic cough have been implicated in the development of stress urinary incontinence (SUI).[6]

Anatomically, the lower urinary tract is comprised by the bladder and urethra. For example, the female urethra is a short conduit 4 cm long and 6 mm in diameter that is suspended by periurethral fascia and pelvic ligaments. Urinary continence is maintained by internal and external sphincters with suburethral support from the anterior vaginal wall and endopelvic fascia.[4] This "hammock" function compresses the urethra against the anterior vaginal wall in moments of increased intra-abdominal pressure and ultimately prevents leakage of urine. When this support is lost urethral hypermobility occurs a key underlying mechanism of stress urinary incontinence (SUI).[7]

For normal urination to occur, there must be coordinated contraction of the detrusor and relaxation of sphincter. These can occur with urethral hypermobility or intrinsic sphincter deficiency if the bladder pressure exceeds closure pressure at the level of the urethra. These mechanisms, which arise from support loss or damage to sphincter components, commonly overlap complicating both

diagnosis and management.[8,9]

In conclusion, SUI is a common and multifactorial condition with major public health consequences for women. SUI is generally caused by urethral hypermobility and/or intrinsic sphincter deficiency and is affected by poor lifestyles, aging, hormonal status changes after delivery (such as prolapse) or anatomical factors. Statins have emerged as a highly efficient treatment for hypertension, and understanding the disease's epidemiology, risk factors, and pathophysiological mechanisms are key to adequate diagnosis and management strategies.[9]

Urethral mobilization assessment has been established as a cornerstone in the evaluation of stress urinary incontinence (SUI) and enables the differential diagnosis of different pathophysiologic mechanisms underlying loss of continence. Clinical and urodynamic parameters have traditionally been used to assess function and mobility of the urethra (pad test, Q-tip test or urodynamic studies). Although these approaches are frequently employed, they have limitations which restrict their clinical utility.[10]

The pad test is a quantitative procedure recognized by the International Continence Society for measuring urinary loss, in which the weight of highly absorbent pads containing liquid is measured before and after controlled physical activities. It can be performed over 1 hour or 24 hours, with established cut off values to characterize severity. The test offers objective measurements, but can be time-consuming and uncomfortable for patients. In addition, because results may also rely on hydration status, bladder volume and stress level factors as well as making it impractical for everyday clinical utilization.[8]

The Q-tip test is another commonly used clinical examination for assessing urethral mobility. In this procedure, a lubricated cotton swab is inserted into the urethra and positioned at the level of the bladder neck. The patient is then instructed to strain or perform a Valsalva maneuver, and the angle of displacement of the swab is measured relative to the horizontal axis. A rotation angle of ≥ 30° is generally considered indicative of urethral hypermobility. The test using a Q-tip is simple, cheap and done in an outpatient setting. 10 However, it is invasive of patient comfort and operator-dependent. Also, studies indicate that its diagnostic accuracy is limited due to its failure of accurately aligning the dynamic interdependence between urethral mobility and continence mechanisms.[11]

Detrusor Activity, Bladder Compliance and Urethral Pressure in Urodynamic Studies (UDS) remain the gold standard for quantitatively assessing lower urinary tract functioning, specifically detrusor activity or bladder compliance and urethral pressure. UDS can also differentiate between urethral hypermobility/extrinsic sphincter deficiency and intrinsic sphincter deficiency for Stress urinary incontinence (SUI). But the procedure is invasive, expensive and not always easy to access for routine or first evaluation. Moreover, urodynamic results may not adequately represent actual incontinence events. Other evaluations, including the Marshall–Bonney and Bonney tests, measure bladder neck support manually to aid in predicting surgical results. They are subjective and without routine standardised validation, although they do provide some level of clinical intelligence.[12,13]

In lumping up, although we mentioned and widely used potencies as the external pad test, Q-tip test and more invasive urodynamic studies for decades there are pitfalls associated to use: invasiveness, reproducibility, patient comfort and overall practicability. The constraints associated with conventional diagnostic methods have since been the key motivators in exploring novel tools that offer greater accuracy, less invasiveness and more patient-based approaches. In this paradigm, pelvic floor ultrasound (PFU) have been

proposed as a practical alternative in the evaluation of urethra mobility and it has the capability to dynamic imaging in real-time with comparable reproductivity of parameters trying to address some issues encountered by all gold standard techniques.[10,12,13]

Over recent years, pelvic floor ultrasound (PFU) has proven to be a useful tool for the diagnosis of pelvic floor disorders including stress urinary incontinence. Originally developed for obstetrics and gynecology, its applications in urogynecology have now expanded as it enables dynamic and non invasive imaging. PFU permits the visualization of both the anatomical and functional properties of the components around bladder neck, urethra and pelvic support structures allowing for an accurate assessment of urethral mobility.[11]

Transperineal, translabial, transabdominal or transvaginal ultrasonography techniques can be used for PFU. While a variety of these techniques exist, transperineal ultrasound (TPUS) has become the most frequent used method for measuring urethral mobility in women presenting with SUI. In TPUS, probe is placed in perineum (or labia majora) to obtain sagittal and axial views of bladder, urethra and symphysis pubis. Real time imaging employing maneuvers such as Valsalva straining or coughing can visualize displacement of the bladder neck and urethra. This is one of the reasons that makes TPUS a particularly useful tool for identifying and monitoring dynamic changes, including symptoms related to them, such as urinary leakage.[11,13,14]

Several measurable parameters have been proposed for PFU in the evaluation of urethral hypermobility:[15,16]

- Bladder Neck Descent (BND): BND refers to the vertical displacement of the bladder neck from rest to straining. A descent greater than 24 mm has been associated with urethral hypermobility and stress urinary incontinence (SUI).
- Urethral Rotation Angle (URA): URA is defined as the change of the urethral angle regarding horizontal axis between rest and Valsalva maneuver. Rinaldi et al. cut-off value of ≥ 41.56° predictive for SUI with high sensitivity and specificity (2020).6
- Retrovesical Angle (RVA): RVA refers to the angle formed between the proximal urethra and the posterior bladder wall. An RVA of ≥ 130.57° has been correlated with urethral hypermobility in women with stress urinary incontinence (SUI).

PFU is a pure numerical computation that can be reproduced between different operators, making PFU a reliable diagnostic modality if performed under standardized protocols.

Compared with conventional methods such as the Q-tip or pad test, PFU offers several clinical advantages. It is non invasive, thereby avoiding the discomfort and risk of infection associated with urethral instrumentation. In addition, PFU provides dynamic imaging of pelvic floor structures during physiological maneuvers, allowing a more accurate reflection of real-life conditions in which urinary leakage occurs. In addition, PFU offers anatomic correlation that benefits not only diagnosis but also surgical planning and postoperative follow-up. ρrecent research has shown that PFU is better or at least equivalent to the conventional methods in terms of diagnostic performance. Xiao et al. (2019) showed that BND and URA achieved sensitivity and specificity above 90% in detecting urethral hypermobility. Turkoglu et al. (2022) also showed that BND combined with URA was more accurate than pad test These results suggest PFU has the potential to recede upfront in assessment for stress urinary incontinence (SUI).[10,17,18]

PFU is a non-invasive, accurate and an easy practice for assessing urethral mobility

in female SUI patients. By providing real-time dynamic imaging and reproducible parameters such as BND, URA, and RVA, PFU addresses many limitations of conventional diagnostic methods. As more data emerge, PFU is becoming a well regarded adjunct device in the diagnosis and treatment plan of urethral hypermobility.[15,18]

As more data emerge, PFU is becoming a well regarded adjunct device in the diagnosis and treatment plan of urethral hypermobility. In summary, all evidence points to PFU having equal or better diagnostic accuracy while providing less discomfort and fewer invasive procedures.[15,18]

One of the earliest comparative studies proved strong correlation between PFU and Q-tip test to assess urethral mobility. Long et al. (2023) then suggested extensive agreement with a limited number of subjects achieving consistent reproducible measurement reporting an overall correlation coefficient (r = 0.91) between Q-tip test angles and measured bladder neck descent from PFU, providing robust evidence that ultrasound provides an acceptable alternative. The study suggested the use of cut off value of 13.3 mm bladder neck descent to identify urethral hypermobility concluding that PFU may be used as objective and non-invasive alternative method in place of Q-tip test.[19]

Later studies pointed out the importance of PFU parameters as BND and URA. Xiao et al. For detecting SUI The cutoffs of BND > 24 mm and URA ≥ 41.56° were found to have sensitivity and specificity above 90% (2019). Similarly, Rinaldi et al. (2020) reported significant associations of the urethral rotation angle (URA) and retrovesical angle (RVA) with urethral hypermobility, providing adequate cut off values to support their implementation in clinical settings.[5]

Comparisons with the pad test have also supported PFU's utility. Turkoglu et al. (2022) found that the combination of BND and URA achieved higher diagnostic accuracy than the pad test in identifying urethral hypermobility. This suggests that PFU may not only serve as an alternative to conventional leakage quantification methods but may also outperform them, particularly in the dynamic assessment of real life stress maneuvers.[4]

Urodynamic studies must be considered the gold standard in lower urinary tract dysfunction evaluation, but they are too invasive, expensive and not widely available for many practice settings. PFU appears well correlated with urodynamic findings, especially for differentiation between urethral hypermobility and intrinsic sphincter deficiency. Although urodynamic studies provide functional data that extend beyond anatomical assessment, PFU offers real time visualization of anatomical changes during stress maneuvers. In this way, it helps bridge the gap between structure and function in a more patient friendly and less invasive manner.[16]

Overall, available evidence shows that PFU is highly accurate for detecting urethral hypermobility. It correlates tightly to traditional measures like the Q-tip test and urodynamic studies while having unique benefits in terms of non-invasiveness, reproducibility, and dynamic assessment. These findings support PFU as an effective and reliable alternative to conventional diagnostic techniques, with increasing potential for integration into routine urogynecological practice.[10]

It can be concluded that pelvic floor ultrasound (PFU) has potential as a diagnostic tool in urogynecology, however, its future development needs more refinement and standardization. The lack of universally acceptable cut-off values for bladder neck descent (BND), orethral rotation angle (URA) and retrovesical angle (RVA) is one of the most important challenge in contemporary practice. Different studies have proposed varying threshold values,

which limits the generalizability of the findings and complicates the integration of PFU into clinical guidelines. Consequently, we recommend future research towards the establishment of standardized measurement protocols and consensus-based cut off values that can be reproducibly adapted to heterogeneous populations.[20]

Technologies will also build the future of PFU. Three dimensional (3D) and four dimensional (4D) ultrasound is useful for anatomical assessment of the urethra as well as functional evaluation of the pelvic structures, with improved imaging detail. Such advancements could enhance diagnostic accuracy, decrease inter operator variation and permit easier treatment outcome monitoring. Also, deep learning with AI and machine learning of imaging techniques has a lot of potentials. Automated algorithms may help with detecting anatomical landmarks to calculate relevant angles for objective and reproducible measurements. This method could reduce observer bias and further improve the robustness of PFU in clinical settings.[15]

Apart from diagnosis, PFU has a significant role to play in treatment planning and postoperative follow up. Ultrasound, for example, may be used to determine changes in bladder neck position and retrovesical space complications during mid urethral sling procedures and may predict surgical outcomes and complications such as tape malposition and recurrence of symptoms. Likewise, PFU can be added to conservative management strategies involving pelvic floor muscle training, allowing for real-time monitoring of treatment response. Ultimately, PFU will establish itself as a widely accepted practice as procedures for measuring it become standardized and technological advances 3D/4D imaging and AI-aided analysis fusion becomes routine clinical practice that expands its application in diagnosis to include therapeutic monitoring. Combined, these innovations are poised to place the PFU as an essential option in the holistic management of stress urinary incontinence and other pelvic floor disorders.[15]

Conclusion

Purpose: Pelvic floor ultrasound (PFU) is a non-invasive imaging modality which may offer considerable potential in the assessment of urethral mobility in females with stress urinary incontinence (SUI). Bladder neck descent, urethral rotation angle and retrovesical angle are reliable markers correlating well with symptoms and established diagnostic tests. PFU is also useful for postoperative assessment such as recurrence risk after mid urethral sling treatment and controlling conservative management outcomes. Nevertheless, its use in clinical practice outside these parameters is limited by methodology heterogeneity, absence of standardization and cut off values. Subsequently, more confirmatory studies and development of consensus guidelines at international level should focus on recurrent findings to increase reproducibility as well as implementation into clinical practice.

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Institutional Review Board Statement

As this study was a literature review, ethical approval was not applicable.

Conflicts of Interest

Conflict of interest The authors declare no conflict of interest.

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