Review

Current Urology

OPEN

A comprehensive review of conservative therapies for female stress urinary incontinence: Advancements, efficacy, and future directions

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Abstract

Pelvic floor dysfunction poses a significant challenge to women worldwide. Female urinary incontinence is one of the most prevalent types of pelvic floor dysfunctions, affecting at least 50% of females, particularly those who are pregnant or menopausal. Among the various urinary incontinence subtypes, stress urinary incontinence takes the lead, characterized by involuntary urine leakage during activities that increase intra-abdominal pressure, such as sneezing, coughing, laughing, or exercising. This comprehensive review explores the latest advancements and critical insights into conservative treatments for stress urinary incontinence. Stress urinary incontinence symptoms result in profound physical and psychological consequences for individuals and impose a substantial medical and economic burden on society; however, only 5%–10% seek professional help. This narrative review meticulously examines a spectrum of interventions, ranging from lifestyle modifications to emerging modalities, such as laser treatment and electroacupuncture.

Keywords: Stress urinary incontinence; Conservative treatments; Pelvic floor muscles training

1. Introduction

Since the mid-1990s, pelvic floor dysfunction diseases have emerged as a prominent category among the top 5 chronic diseases worldwide. Urinary incontinence (UI) is one of the most prevalent symptoms in this group.[1] Pelvic floor dysfunction diseases, notably UI, affect a substantial proportion of the global female population, with estimates indicating a prevalence of at least 50%.[2] Nevertheless, the societal stigma surrounding the discourse on UI symptoms contributes to the hesitancy of numerous women to seek professional medical care, and only 15% of affected individuals present to hospitals for expert assistance.[3]

According to the definitions provided by the International Society for Urinary Control and International Urogynecological Association, UI is characterized as "a complaint of any involuntary urinary leakage.[4]" Urinary incontinence is categorized into 3 types: urge urinary incontinence, stress urinary incontinence (SUI), and mixed urinary incontinence.[4] Stress urinary incontinence, which constitutes 23.7% of the cases,[2] is the most prevalent subtype. It involves involuntary urine leakage during activities that increase intra-abdominal pressure, such as sneezing, coughing, laughing, or exercising.[5] A recent study[6] revealed that the incidence of female UI is 21.2 per 1000 person-years in China.

Numerous potential pathogenic factors contribute to SUI development. Most female patients present with a combination of diverse factors. Stress urinary incontinence not only inflicts substantial damage on the physical and psychological well-being of female patients but also imposes a considerable medical and economic burden on society,[7] evolving into a notable social issue.[7] With the acceleration of population growth and the aging of societies globally, SUI has emerged as a pervasive public health concern, particularly in China.

Treatment modalities for SUI include both conservative and surgical approaches, and conservative treatments are initially preferred for all types of UI.[8] Conservative approaches are characterized by noninvasiveness, cost-effectiveness, minimal complications and risks, outpatient application, patient empowerment, and high efficacy in mild-to-moderate cases.

2. Behavioral therapy

Lifestyle interventions should be prioritized as an initial step.[9] These interventions encompass measures such as reducing the body mass index (BMI),[10] discontinuing smoking, abstaining from coffee consumption, and avoiding strenuous physical activities that elevate intra-abdominal pressure, among others.[11] Notably, Sung et al.[12] conducted a randomized clinical trial and observed that combining behavioral therapies with surgical interventions yielded superior cure rates compared to surgery alone, as evidenced by a follow-up period of 1 year. Obesity has emerged as a significant risk factor for SUI in women,[13] and mitigation of SUI-related symptoms is achievable through BMI reduction.[13] Ptak et al.[14] demonstrated that both BMI and waist-to-hip ratio can affect the effectiveness of pelvic floor muscle training (PFMTs), asserting that outcomes are more favorable when BMI is <30 kg/m^2 and waist-to-hip ratio is <0.8. Pang et al.[15] observed a significant association between SUI and visceral adipose index among

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Current Urology, (2025) 19, 2, 84–89

Received January 9, 2024; Accepted October 21, 2024.

http://dx.doi.org/10.1097/CU9.0000000000000270

adult women. Previous investigations[16] have underscored a direct correlation between a 5-unit increase in BMI and a substantial 20%–70% increase in the risk of UI. Recent meta-analyses[17,18] indicate that bariatric surgery is an effective option for addressing UI in women with obesity, particularly in Asian populations.

Grip strength (GS) is an indicator of overall muscle strength that tends to decline after middle age.[19] Lower levels of GS was associated with an increased prevalence and severity of SUI. A study reported[20] that a 5% decrease in GS was associated with increased odds of de novo or persistent SUI (adjusted odds ratio [OR], 1.60, $p = 0.047$). Conversely, a 5% increase in appendicular lean mass (adjusted OR, 0.17; $p = 0.004$) and a 5% decrease in fat mass (adjusted OR, 0.53; $p = 0.01$) were associated with decreased odds of de novo/persistent SUI.[20] The living environment is closely associated with the occurrence of various chronic diseases, such as kidney stones and coronary heart disease, which are closely linked to exposure to nephrotoxic metals in the environment. Ni et al.[21] analyzed information from 4406 females in the National Health and Nutrition Examination Survey spanning from 2005 to 2016. They reported a positive correlation between the prevalence of UI and exposure to cadmium or lead. As the cadmium concentration in the blood increased, the OR of SUI occurrence also increased, reaching a peak at 4 μg/L. Mercury was not significantly associated with the occurrence of SUI or urge urinary incontinence. Other lifestyle adjustments include managing constipation and altering bowel habits, controlling chronic conditions such as diabetes and chronic obstructive pulmonary disease, quitting smoking, reducing the consumption of caffeinated beverages and alcohol, and avoiding or minimizing activities that increase abdominal pressure.

3. Pelvic floor muscles training

Pelvic floor muscle (PFM) function is akin to a "hanging net," providing essential support to the urethra, bladder, vagina, uterus, rectum, and other tissues, thereby maintaining their normal positions to execute their respective functions.[22–24] Impairment of PFMs, ligaments, and adjacent tissues results in diminished support for the pelvic organs, giving rise to symptoms, including UI and pelvic organ prolapse (POP). Pelvic floor muscle training involves conscious, repetitive contractions, and relaxations of the PFMs, increasing muscle tension and introducing urethral resistance to achieve the expected efficacy in treating female SUI.[25] Pelvic floor muscle training is the primary conservative approach for treating SUI in women because of its increased feasibility, reduced complications, and anticipated subjective and objective cure rates.[26] A Cochrane review[27] reported that PFMT significantly contributed to the cure or improvement of symptoms related to SUI and other types of UI. Pelvic floor muscle training has shown potential in reducing the frequency and quantity of leakage episodes during urine pad tests in clinical settings, as well as alleviating symptoms based on UI-specific questionnaires. In a meta-analysis by Lu et al.,[28] PFMT demonstrated superior efficacy for symptoms related to UI compared to routine nursing, particularly in prenatal and postnatal women. Women exhibiting inadequate self-management skills and a lack of awareness regarding supervision or those without professional, long-term training guidance may adhere inconsistently to PFMT, resulting in suboptimal outcomes for some individuals. Advancements in Internet technology and economic development have led to the implementation of specialized applications to actively and promptly guide, manage, and supervise patients following PFMT. Pelvic floor muscle training is well-established for mild-to-moderate SUI; however, some researchers have suggested that supervised PFMT may be more effective.

Many patients opt to actively engage with professional organizations or hire personal coaches to seek expert assistance at a substantial cost. In a randomized clinical trial conducted by Dumoulin et al.,[29] 362 community-dwelling women were recruited and divided into 2 groups: 178 women who received group-based PFMT and 184 women who received individual sessions. Following a 1-year follow-up, they observed that individual- and group-based PFMT exhibited similar effectiveness for all secondary outcomes. This study suggests that group-based PFMT is not inferior to individual PFMT for the treatment of SUI and mixed urinary incontinence in older women. Despite variations in the outcomes of different studies, it is evident that PFMT, whether delivered individually or in groups, remains a valuable and effective intervention for SUI in women. The choice between individual- and group-based PFMT may depend on factors such as patient preferences, resource availability, and specific goals of the intervention.

Biofeedback involves diverting electromyography signals into timely visual and auditory cues, whereas while female patients with SUI engage in PFMT.[30] This technique facilitates precise PFMT guidance and improves patient outcomes. Electromyography biofeedback (EMG-BF), a subtype of biofeedback therapy,[31,32] was the subject of a meta-analysis[33] that integrated 21 studies encompassing 1967 patients with EMG-BF + PFMT versus 1898 women with PFMT alone. The pooled results indicated that PFMT combined with EMG-BF achieved superior outcomes compared with PFMT alone in female SUI. In a multicenter randomized controlled trial, Hagen et al.[34] compared 300 female patients treated with PFMT plus EMG-BF with 300 patients treated with PFMT alone at a 24-month follow-up. The results showed no significant evidence of a notable difference in UI severity between the 2 groups, and they reported that routine PFMT associated with EMG-BF was not recommended. A subsequent trial by Hagen et al.[35] reached similar conclusions, affirming that PFMT alone is the preferred option for female patients owing to lower complications and costs. The efficacy of PFMT is intricately linked to body posture. A clinical predictive model developed by Brooks et al.[36] demonstrated that female patients with better bladder support in the standing position and less severe symptoms were more likely to experience successful outcomes of PFMT.

Electrical stimulation (ES) involves the activation of PFM groups and nerves through an electric current, leading to the passive enhancement of PFM strength on a regular basis.[37] A meta-analysis revealed that ES may improve short- and long-term incontinence quality of life for female SUI, but it appears to provide only short-term reduction in urine leakage and long-term reduction in the frequency of incontinence episodes.[38] Biofeedback ES (BES) is a therapeutic approach that combines ES with biofeedback, wherein physiological changes resulting from the stimulation of PFMs are fed back to the clinician. Subsequently, based on individual patient characteristics, varying pulse widths, frequencies, and energy levels of ES were administered to promote passive contraction movements in the PFM group, enhancing their excitability and improving both the strength and urinary control of these muscles. Li et al.[39] utilized ES to treat postpartum women and observed a significant improvement in muscle strength with ES treatment. However, a prospective randomized controlled trial reported no significant difference in PFM strength between the ES and control groups. In a randomized controlled trial conducted by Lv et al.,[37] 60 patients who underwent POP surgery were included. Among them, 30 received conventional care and the remaining 30 received

BES. They reported that BES treatment significantly improved urinary function, PFM strength, and quality of life. The simultaneous integration of necessary passive muscle contractions (ES/BES) with PFMT and periodic assessments can enhance treatment effectiveness.

4. Energy-based treatment

Laser therapy is increasingly regarded as a noninvasive intervention for gynecological diseases and has emerged as a preferred alternative therapy. Recently, lasers have been used to treat various gynecological conditions, including genitourinary syndrome of menopause, vulvovaginal atrophy, vaginal relaxation, and UI. Two main types of lasers are commonly utilized: the CO_2 laser and vaginal erbium ER: YAG laser (VEL).[40] The efficacy of intravaginal CO_2 lasers for the treatment of UI was first reported in 2009. It not only tightens the anterior fascia but also elevates and supports the bladder bottom and urethra, thereby reducing urethral hyperactivity and improving urethral closure functions.[40] A clinical trial conducted by Gaspar et al.[41] using VEL for treating type III SUI demonstrated promising results in the International Consultation on Incontinence Questionnaire—Urinary Incontinence Short Form (ICIQ-SF) and 1-hour pad weight test; all patients tolerated the therapy well, and the adverse effects were mild and transient. They suggested that VEL is a potential alternative to invasive surgical treatments. The pooled results of a meta-analysis[42] that included 16 studies with 899 patients with SUI showed that laser therapies (VEL and CO_2 laser) achieved better outcomes based on the median changes in the ICIQ-SF score and 1-hour pad weight test results. In addition, the Pelvic Organ Prolapse/Urinary Incontinence Sexual Function Questionnaire-12 score increased after laser treatment. Zhang et al.[43] conducted a meta-analysis in 2023, which incorporated 6 randomized controlled trials (RCTs) and 577 SUI patients in this study, and CO_2 laser did not significantly improve the ICIQ-SF score at all visits. They observed no prior efficacy of energy-based therapy compared to placebo intervention for SUI. Different studies used various research designs, CO_2 lasers treatment parameters, follow-up times, and evaluation criteria. However, the efficacy of CO_2 laser therapy remains controversial based on short-term clinical studies. Additionally, the long-term sequelae in the vulva and vagina remain unclear. Therefore, definitive conclusions regarding the effectiveness and safety of treatment can only be drawn through rigorous controlled studies with meticulous designs and extensive sample collection.

In recent years, radiofrequency (RF) therapy has been widely used to treat vaginal laxity. Unlike lasers, RF operates via RF waves in Hertz. Its mechanism can be summarized as releasing RF energy at predetermined tissue depths, promoting the synthesis of various proteins such as heat shock proteins, matrix metalloproteinases (MMP), collagen, and elastin neogenesis, remodeling of the extracellular matrix (resulting in increased proportions of smooth muscle and collagen), and deposition of hyaluronic acid. Additionally, the application of thermal energy to the vaginal wall stimulates epithelial cell proliferation, angiogenesis, and the formation of intrinsic collagen and enhances vaginal lubrication.[44] The application of thermal energy to the vaginal wall stimulates epithelial cell proliferation, promotes angiogenesis, and enhances the formation of intrinsic collagen, thereby improving vaginal lubrication.[45,46] Leibaschoff et al.[46] reported statistically significant improvements in ICIQ-SF and Urogenital Distress Inventory-6 scores following temperature-controlled RF treatment. A randomized controlled trial[45] compared the efficacy of microablative RF (MRF) with PFMT in treating SUI. Thirty-nine patients were assigned to the PFMT group, 39 to the MRF group, and 39 to the PFMT + MRF group. After treatment, significant improvements were observed in the urinary symptom questionnaire scores for all 3 groups, with the RF + PFMT group showing the greatest improvement. Compared with the PFMT group, both the RF and RF + PFMT groups exhibited significantly higher subjective cure rates. There was a noticeable decrease in the 1-hour pad test volume in all patients, with no statistically significant difference. No severe complications were reported in any patient. One patient in the MRF group experienced mild vaginal burning, which resolved spontaneously without specific intervention. Radiofrequency can alleviate SUI symptoms in the short term. However, the number of clinical studies applying RF to SUI is limited, and the quality of published research is low. Therefore, high-quality studies are needed to investigate the effectiveness and safety of RF and provide a solid foundation for clinical practice.

5. Magnetic stimulation

Magnetic stimulation (MS) is a noninvasive, effective, and safe therapeutic modality for SUI, which was approved by the Food and Drug Administration in 1998.[47] This approach involves altering the magnetic field, resulting in substantial enhancement of PFMs and endurance through repeated activation of the terminal motor nerve fibers and motor end-plates.[47] Lim et al.[48] conducted an RCT in which 120 SUI were incorporated (60 in the pulsed MS [PMS] group and 60 in the sham PMS group), and observed higher treatment satisfaction in the PMS group than in the sham group. The PMS group felt much or very much better, according to Patient Global Index of Improvement. A meta-analysis[49] of 6 RCTs found that the MS group exhibited higher quality-of-life scores and lower ICIQ-SF scores compared with the placebo group. Moreover, the MS group exhibited a higher objective cure rate. In addition, MS treatment significantly reduced the number of UI episodes and urine loss in pad tests. No significant treatment-related adverse reactions were associated with MS. In the short-term, MS was demonstrated to have satisfactory efficacy for SUI without significant treatment-related adverse effects. However, clinical data on the long-term effectiveness and safety of MS are lacking.

6. Incontinence pessary

For a long time, pessaries have been widely employed in the treatment of POP, demonstrating satisfactory efficacy in both long- and short-term follow-ups.[50] There are various types of pessaries, and we selected them based on the patients' symptoms and sexual activity. The pessary is placed within the vagina and supports the pelvic floor structures to achieve therapeutic effects, particularly in patients who refuse or are unsuitable for surgery. Recently, pessaries have been used to treat SUI. Incontinence pessaries support the urethra and bladder wall and extend the urethral length, thereby increasing the resistance around the urethra and preventing SUI.[51] According to a retrospective clinical study by Hall et al.[52] in 2023, compared with PFMT and surgery, the incontinence pessary had the lowest treatment failure rate. Another study reported the effective rate of incontinence pessary in treating SUI to be 83%, with 76% of women continuing use after 1 year.[53] Proper wearing and continuation of pessaries are closely associated with patient satisfaction.[53] Factors associated with the inability to wear pessary correctly include widened vaginal openings, vaginal

length < 6 cm, and posterior pelvic compartment defects.[54] In February 2021, the Canadian Obstetrics and Gynecology Association[55] updated guidelines for pessary, stating its high success rate and low complication rate in treating SUI, advocating it as a first-line treatment. The main complications of a pessary include increased vaginal discharge, de novo dysuria, and natural falling from the vaginal opening. In addition, pessaries are suitable for patients with SUI and POP. However, owing to the limited level of evidence, the National Institute for Health and Care Excellence does not recommend its use.[56] Finally, clinicians should provide comprehensive instructions to patients regarding the proper management of the pessary to ensure effective symptom relief. Patients should also be informed of common reactions or discomfort when using pessary devices and their corresponding management methods.

7. Electroacupuncture

Acupuncture, an essential component of traditional Chinese medicine with a history of more than 2500 years, encompasses various techniques, including electroacupuncture (EA). Electroacupuncture has been widely utilized and has shown satisfactory efficacy in treating a broad spectrum of diseases. However, the specific mechanism of action of EA in SUI treatment remains unclear. Studies have reported that EA may facilitate reinnervation and strengthen PFMs, thereby improving the symptoms of SUI.[57,58] In a multicenter randomized controlled trial conducted by Liu et al.[59] in 2017, 252 patients with SUI received EA treatment and 252 received sham EA. After 6 weeks of treatment, they observed a greater decrease in mean urine leakage in the EA group than in the sham EA group. Additionally, they reported that the change in mean 72-hour incontinence episodes from baseline was greater in the EA group than in the control group, with between-group differences of 1 episode in weeks 1–6 and 2.1 episodes in weeks 27–30. No serious treatment-related complications were observed in either group. A meta-analysis[60] published in 2020 demonstrated that EA effectively ameliorated the symptoms of SUI and reduced 1-hour urine leakage. A meta-analysis[61] including 4 RCTs and a total of 690 patients was conducted to compare acupuncture treatment with the sham acupuncture group. The results demonstrated that acupuncture significantly outperformed the sham acupuncture group in reducing mean urine leakage, improving the 1-hour pad test, decreasing 72-hour incontinence episodes, lowering ICIQ-SF scores and enhancing patient self-evaluation. The incidence of complications (primarily pain, hematoma, and infection) did not differ significantly between the 2 groups. Currently, most studies are short-term, with small sample sizes. Although acupuncture has shown promise in improving the symptoms of SUI in the short term, long-term follow-up data are lacking. Similarly, existing studies were predominantly conducted in Asia, with the majority of participants being Chinese, which could introduce selection bias. Electroacupuncture treatment still faces significant challenges, and further research is required to demonstrate its long-term efficacy and mechanisms of action.

8. Drug treatments

No pharmacological treatments have been approved for SUI by the Food and Drug Administration, there are no approved pharmacological treatments for SUI. Duloxetine hydrochloride was approved by the European Medicines Agency in 2004 for the treatment. Duloxetine hydrochloride, a dual serotonin and norepinephrine reuptake inhibitor, can increase bladder capacity and striated urethral sphincter activity, presumably through central actions in the spinal cord of cats.[62] A meta-analysis[63] reported a significantly greater decrease in the frequency of incontinence episodes in the duloxetine group than in the placebo group. Common adverse events include nausea, constipation, dry mouth, and fatigue. Physicians should offer drug treatment as an option for patients with SUI who do not respond to other conservative treatments and wish to avoid surgical intervention. However, they should strictly adhere to contraindications and provide detailed information on potential adverse events. It is crucial to acknowledge that drug treatments are subject to ongoing research and that their effectiveness may vary from person to person.

Previous studies[64–66] suggested that a reduction in local estrogen levels may lead to PFMs atrophy and degenerative changes in the lower urinary tract. Animal experiments[67] have indicated that after the local application of appropriate doses of estrogen in the vaginal canal of SUI mice, the expression of type I collagen, type III collagen, elastin, tissue inhibitor of metalloproteinase-1, and tissue inhibitor of metalloproteinase-2 increased, while the expression of matrix metalloproteinase-2 and matrix metalloproteinase-9 decreased. Additionally, this treatment increased the leak point pressure and abdominal leak point pressure in SUI mice.

A Cochrane systematic review[68] indicated that local estrogen administration may ameliorate UI symptoms, with no reports of severe short-term adverse events. However, high-quality evidence supporting the use of local estrogen preparations in SUI is lacking. Systemic hormone replacement therapy is not recommended for SUI treatment. Strict attention should be paid to contraindications when using local estrogen preparations. Caution should be exercised during use, with continuous follow-up after medication. If adverse events become intolerable or symptoms recur, medication adjustments should be made promptly.

9. Conclusions

In the management of SUI, careful consideration of related comorbid diseases, such as POP and overactive bladder, is essential, as they significantly impact outcomes. Addressing these comorbid conditions not only improves the overall effectiveness of SUI management but also ensures a more comprehensive and tailored approach to patient healthcare, promoting better outcomes and enhancing quality of life. Pelvic floor muscle training remains the primary choice among conservative treatments for SUI in women, and supervised PFMT may be better. Patients should select treatment options judiciously based on their individual factors and conditions. Energy-based therapies are acknowledged for their noninvasive nature; however, they are not recommended as first-line therapies, and their long-term effects and safety still require validation. The landscape of treatments for female SUI is evolving toward diversification, individualization, efficiency, and minimally invasive approaches. Comprehensive diagnostic and personalized treatment strategies should be devised for patients with SUI to optimize treatment efficacy.

Acknowledgments

None.

Statement of ethics

Not applicable.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Funding source

This work was supported by the National Key Research and Development Program of China, no. 2021YFC2009100; Science and Technology Department of Sichuan Province Project, no. 23ZYDF2049; and Sichuan Provincial Health Commission Project, no. 21ZD002 (all to XN).

Author contributions

CL, XN: Project development, data collection, manuscript writing, and editing.
All the authors have approved the final manuscript.

Data availability

This narrative review is based on data and studies that are publicly available in peer-reviewed journals and online databases, as referenced throughout the manuscript.

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How to cite this article: Luo C, Niu X. A comprehensive review of conservative therapies for female stress urinary incontinence: Advancements, efficacy, and future directions. *Curr Urol* 2025;19(2):84–89. doi: 10.1097/CU9.0000000000000270