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Application progress of pelvic floor ultrasound in acupuncture treatment of female stress urinary incontinence

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Abstract: As the prevalence of female stress urinary incontinence (SUI) increases year by year, acupuncture, as one of the non-surgical treatment methods of Sui, has significant clinical efficacy and is worthy of promotion and application in clinical treatment. As a noninvasive, convenient, low-cost and highly acceptable imaging method, pelvic floor ultrasound can accurately and clearly observe the pelvic floor structure of patients, provide objective imaging data for clinical diagnosis and evaluation, and clearly evaluate the clinical efficacy of acupuncture in the treatment of Sui. This article mainly discusses the application progress of pelvic floor ultrasound in the treatment of female stress urinary incontinence with acupuncture.

1. Introduction

Stress urinary incontinence (SUI) is a common urinary system disease in middle-aged and elderly women. It is usually defined as the phenomenon of involuntary urine outflow due to the increase of intra-abdominal pressure in patients. The number of its incidence is increasing, and relevant reports show that the incidence of adult women in China can reach 19% [1]. However, due to the lack of understanding of the disease, the number of patients in early treatment is relatively small. Generally, patients are treated only after they have clinical symptoms. What's more, they are directly treated by surgery when their normal life is seriously affected, so they miss the early diagnosis and noninvasive intervention treatment period. At present, there are many complications after surgical treatment, and the long-term curative effect is not significant. Non surgical treatment makes up for this defect. Non surgical treatment includes pelvic floor muscle training, electrical stimulation, lifestyle intervention, traditional Chinese medicine physiotherapy (acupuncture, moxibustion), drug treatment, etc. Acupuncture and moxibustion therapy, the effect is more significant. At present, there are many ways to diagnose and evaluate the efficacy of acupuncture and moxibustion in the treatment of Sui, such as patient self-report, subjective diagnosis by doctors, 1-hour urine pad test, urodynamic examination, urinary incontinence questionnaire score (ICI—Q—SF) [2] its subjective degree is high, and it lacks objective diagnostic indicators. Although MRI and X-ray make up for its subjective shortcomings.

However, the female pelvic floor structure cannot be dynamically observed in real time. Therefore, it has largely affected the research progress of acupuncture and moxibustion in the treatment of SUI. Pelvic floor ultrasound has the characteristics of noninvasive, convenient, low cost and high acceptance of patients. It can observe the shape, function and physiological changes of pelvic floor in real time and dynamically. It has high value in the diagnosis of stress urinary incontinence and clinical curative effect observation. Therefore, the application of pelvic floor ultrasound in acupuncture treatment of female stress urinary incontinence is summarized as follows:

2. Theoretical basis of acupuncture and moxibustion for SUI

Stress urinary incontinence (SUI) belongs to the category of "enuresis", "incontinence from urination", "bladder cough" in traditional Chinese medicine. "Lingshu ·nine needles" says: "the bladder is not about drowning", and "the Yellow Emperor's Canon of internal medicine" says that "if the kidney coughs incessantly, the bladder will suffer, the bladder will cough like, and the cough will drown". Therefore, traditional Chinese medicine believes that the disease is located in the kidney and bladder. When the kidney qi and kidney yang are deficient, the gasification function of the kidney is damaged, which affects the fixation of the bladder on urine and causes drowning.

Acupuncture and moxibustion in the treatment of SUI usually takes warming and tonifying the kidney yang, fixing and stopping the residual as the treatment principle. In the treatment, ordinary acupuncture, warm acupuncture, electroacupuncture, heat sensitive moxibustion, moxibustion, combined treatment and other methods are often used. Guanyuan, Sanyinjiao, Zhongji, Zusanli, Qihai, Shenshu and other points are often used for treatment [3]. According to the theory of traditional Chinese medicine, Qihai and Guanyuan can stabilize and arrest the remaining Qi, regulate the Qi machine, and stimulate the menstrual Qi. Sanyinjiao, as an important gynecological acupoint, can supplement the liver and kidney, regulate blood and Qi. Zusanli, as an important health care acupoint, can supplement the spleen, replenish qi, and elevate Yang Qi. Shenshu, as the back Shu point of bladder meridian, can supplement kidney yang. Modern research shows that acupuncture treatment of SUI can regulate the expression of related proteins in pelvic floor tissue, thus improving the metabolism of related proteins, regulating the expression of transcription factor c-Fos in the brain, repairing neural tissue, and regulating intestinal flora, thus improving pelvic floor muscle and other functions [4]. According to animal experiments, stimulating Guanyuan and Sanyinjiao can reduce urinary leakage, mainly by improving the abnormal myoelectric activity of urethral sphincter, bladder detrusor and urethral sphincter function. At the same time, acupuncture at Sanyinjiao can adjust the muscle tension of pelvic floor muscle group, stimulate Guanyuan, Qihai and Zhongji, which can improve the metabolism of patients and enhance pelvic floor muscle strength. The cortex of Shenshu has the distribution of corresponding spinal nerves, which can regulate the sympathetic nerves innervating the urinary bladder storage function [5].

3. Anatomical relationship between pelvic floor ultrasound and SUI

Pelvic floor ultrasound is a commonly used image to observe the pelvic floor structure at present. Two dimensional ultrasound can directly observe and measure the pelvic floor structure and understand the changes of pelvic floor organs in different states. Three dimensional ultrasound can obtain a clear and comprehensive pelvic floor anatomy, more clearly and intuitively observe the changes of pelvic floor structure under different action states, quantitatively evaluate the pelvic floor function by measuring the changes of bladder neck, levator ani muscle, pelvic diaphragm hiatus area, and then accurately evaluate the anatomical changes of urethra and bladder. Four dimensional ultrasound superimposes spatial and temporal parameters on the basis of three-dimensional ultrasound to display dynamic three-dimensional images. It can display more information than two-

dimensional and three-dimensional ultrasound, opening up a new way to observe the function and anatomical structure of pelvic floor.

Women's normal urine storage and micturition are mainly completed by the sympathetic and parasympathetic nerves jointly regulating the bladder, internal and external sphincter of urethra, pelvic floor muscles and other structures. Clinically, the most common type of SUI patients is anatomical structure damage, that is, the bladder neck and urethra are damaged, which leads to excessive urethral activity and thus causes SUI[6]. The currently recognized etiological theory is the "drawbridge theory". The so-called "drawbridge" is that the bladder neck and urethra supported by fibromuscular connective tissue (composed of the anterior wall of the inner vagina and pelvic fascia) are connected with levator ani muscle and pelvic wall through the tendon arch of pelvic fascia [7]. Form a hammock like structure, so as to keep the urethra and bladder neck stably in the normal position, so that even if the internal pressure of the bladder increases, the urethral cavity can be effectively closed, so as to prevent urinary outflow. However, when the supporting tissues such as the anterior wall of the internal vagina and pelvic fascia are damaged and cannot resist the increased intra-abdominal pressure, urinary incontinence will occur. It can be seen that in the clinical treatment of SUI, it is particularly important to accurately evaluate the bladder neck mobility and pelvic floor tissue, and pelvic floor ultrasound can clearly detect the pelvic floor structure, which provides a great anatomical basis for the clinical diagnosis and treatment of the disease.

Pelvic floor ultrasound can clearly detect the changes of these structures (lower urethra, bladder, bladder neck). Therefore, it has high value in the diagnosis and evaluation of SUI. The main imaging signs of SUI diagnosed by pelvic floor ultrasound: the formation of bladder neck infundibulum and the mobility of bladder neck. Meanwhile, pelvic floor ultrasound can also measure the area of levator ani hiatus. Levator ani muscle, as the weakest part of female pelvic floor structure, has the function of synergistic urinary control, so it can also be used as an ultrasound index for diagnosis and evaluation [8]. Previous studies have shown that the distance between bladder neck and the lower edge of pubic symphysis is ≥ 2.3cm, and the posterior angle of bladder and urethra at rest ≥ 95 °; Bladder neck rotation angle ≥ 20 °; As long as there are two matches,SUI can be diagnosed[9]. Dietz et al. [10] set the pelvic diaphragm fissure area >25 cm2 in the maximum Valsalva state as the critical value for abnormal pelvic diaphragm fissure expansion. The larger the fissure area, the more significant the symptoms. Dou et al [11] proposed that taking the pelvic diaphragmatic fissure area > 19.5cm2 in the maximum Valsalva state of Chinese women as the reference value of abnormal pelvic diaphragmatic fissure expansion, its sensitivity and specificity are both high, which is more suitable for China's national conditions.

4. Application status of pelvic floor ultrasound in acupuncture treatment of Sui

4.1. Diagnostic role of pelvic floor ultrasound in acupuncture treatment of Sui

At present, the objective imaging methods for the diagnosis of female stress urinary incontinence in clinic are mainly ultrasound and MRI, but MRI cannot dynamically monitor the disease in real time, and the cost is high, which is not easy for patients to accept. The pelvic floor ultrasound can observe the pelvic floor function and pelvic floor structure anatomy in real time and dynamically. In the diagnosis of female stress urinary incontinence, transperineal pelvic floor ultrasound can dynamically observe and quantitatively evaluate the posterior angle of bladder and urethra, bladder neck mobility and other indicators, providing a basis for the prediction and judgment of pelvic floor dysfunction disease. Increased bladder neck mobility is one of the pathogenesis of female stress urinary incontinence, and indicators such as Retrovesical angle (RVA), Bladder neck descend(BND) and Urethral Tilt angle(UTA)can reflect the bladder neck mobility. Wangting et al [12] detected that

the RVA、BND, bladder neck rotation angle and bladder neck downward movement distance of all patients and healthy physical examinees were greater than those of healthy physical examinees under the three-dimensional pelvic floor ultrasound under the resting state and the Valsalva maneuver, indicating that compared with healthy women, there are obvious abnormalities in ultrasound indicators of women with stress urinary incontinence. This index can be used as the basis for judging stress urinary incontinence. Buqiuqiang et al. [13] observed under pelvic floor ultrasound that the Urethral Tilt angle(UTA), bladder neck position, bladder position, and Retrovesical angle(RVA) of SUI puerpera in the resting state were smaller than those of healthy puerpera, and the levator ani hiatus area (LHA)was larger than that of healthy puerpera, while the urethral inclination, levator ani hiatus area(LHA), and Retrovesical angle(RVA)were larger than those of healthy puerpera in the Valsalva state, and the bladder neck positionThe bladder position was smaller than that of healthy parturients; The urethral rotation angle (URA)and bladder neck descend(BND) were greater than those of healthy parturients. At the same time, the formation rate of urethral orifice infundibulum in SUI pregnant women was also higher than that in healthy pregnant women, suggesting that pelvic floor ultrasound can improve the detection rate of urethral orifice infundibulum formation in SUI patients. Liujiangyun et al [14] examined 167 SUI patients (80 with multiple deliveries and 87 with initial deliveries) and 100 healthy women simultaneously with three-dimensional pelvic floor ultrasound to detect bladder neck descent, urethra (inclination angle, bladder posterior angle, rotation angle), bladder detrusor thickness, bladder neck mobility and other parameters. The study found that women with multiple deliveries compared with women with initial deliveries and healthy women. In addition to the bladder neck descent in the resting state, other ultrasound parameters have obvious differences, and with the severity of SUI, the changes of relevant parameters are also obvious, indicating that pelvic floor ultrasound also has a certain value in the diagnosis of the severity of SUI. Minjie et al [15] measured the BND, RVA, and URA under the condition of Valsalva in 120 SUI patients according to the disease grading (28 mild cases, 56 moderate cases, and 36 severe cases), and then compared them with the above pelvic floor ultrasound index parameters of the control group (40 normal people). The study further confirmed that the BND, RVA, and URA have certain diagnostic value for SUI. When only measuring a single parameter, the reference value of bladder neck mobility (the optimal cutoff value is 19.77mm) is greater. Measuring three indicators at the same time can effectively make up for the low sensitivity of a single indicator in diagnosing SUI.

4.2. The role of pelvic floor ultrasound in evaluating the efficacy of acupuncture in the treatment of SUI

In clinical practice, the changes of relevant indicators of patients before and after acupuncture treatment were compared by pelvic floor ultrasound detection, so as to determine the curative effect of acupuncture. To provide a feasible scheme for the treatment of SUI in clinic.

4.2.1. Evaluation of the curative effect of ordinary acupuncture

Minjie et al [16] performed transperineal three-dimensional pelvic floor ultrasound before and after treatment, and recorded the resting state, levator ani hiatus area (LHA) under Valsalva action, distance from bladder neck to lower edge of pubic symphysis, retrovesical angle (RVA), downward displacement distance of bladder neck, urethral rotation angle(URA) and other parameters of patients treated with acupuncture combined with pelvic floor muscle functional exercise. It was found that the area of levator ani hiatus, retrovesical angle(RVA) and bladder neck descend(BND), and the urethral rotation angle (URA)in the acupuncture combined with pelvic floor muscle functional exercise group were smaller than those in the pelvic floor muscle functional exercise group at rest and in Valsalva state (all $p<0.05$). The above ultrasonic parameters changed significantly before and after treatment

under pelvic floor ultrasound monitoring. It shows that acupuncture and moxibustion can improve the effect of SUI rehabilitation treatment in women undergoing vaginal delivery. Mu Liang et al [17] found that after acupuncture treatment in women with mild to moderate SUI, the LHAduring anal constriction was reduced compared with that before treatment ($p<0.05$), and the contractile capacity of pelvic floor muscles was improved by exercise, thus confirming that acupuncture has a clear effect in the treatment of SUI.

4.2.2. Evaluation of therapeutic effect of warm acupuncture

He yuan et al [18] observed and compared the bladder neck mobility (BLM), levator ani muscle hole diameter (LHW), The levels of levator ani muscle thicknes(MLT), levator hiatus area(LHA) in the treatment group (warm acupuncture combined with pelvic floor muscle exercise) and the control group (pelvic floor muscle exercise) before and after treatment under three-dimensional pelvic floor ultrasound. The results showed that the BLM, LHW, LHA decreased and MLT thickened, and the treatment group was more obvious than the control group ($p<0.05$). Thus, the changes of BLM, LHW, LHA, MLT and other parameters under pelvic floor ultrasound confirmed that warm acupuncture can indeed improve the pelvic floor structure and function of SUI patients. At the same time, he [19] also observed and compared Bladder neck descend (BND) of all patients before and after treatment, and found that BND significantly decreased in Valsava state ($p<0.05$), which was consistent with the improvement of patients' clinical symptoms. It further showed that warm acupuncture in the treatment of SUI could effectively improve the pelvic floor function and the ability of urination and urinary control of patients.

4.2.3. Evaluation of the curative effect of heat sensitive moxibustion

Yangxiaobo et al [20] observed and recorded the ultrasound parameters of BND, urethral rotation angle (URA), LHA and other parameters of 120 cases of mild and moderate female stress urinary incontinence before and after treatment under three-dimensional pelvic floor ultrasound, and performed statistical analysis. It was found that the three indicators were improved compared with those before treatment, and the heat sensitive moxibustion combined with Kegel exercise group was significantly better than that of the simple Kegel exercise group ($p<0.05$). Thus, according to the observation and comparison of three parameters of BND, URA and LHA by pelvic floor ultrasound, it was concluded that heat sensitive moxibustion can enhance the clinical efficacy of Kegel exercise. Laizhanhui et al. [21] observed under two-dimensional pelvic ultrasound that the BND, URA and LHA of the two groups treated with heat sensitive moxibustion combined with Buzhong Yiqi granules and taking Buzhong Yiqi granules alone were reduced after 2 months of treatment, and the heat sensitive moxibustion group was significantly smaller than that of the Buzhong Yiqi granules group. It was further confirmed by pelvic floor ultrasound that thermal moxibustion can significantly improve the structure and function of pelvic floor.

4.2.4. Evaluation of the efficacy of Electroacupuncture

Huang Hui et al. [22] observed the BND, bladder urethral posterior angle (PUVA) and URA of 90 postpartum SUI patients before and after electroacupuncture treatment. Under pelvic floor ultrasound, they found that the parameter changes of electroacupuncture combined with Kegel exercise were smaller than Kegel exercise ($p<0.05$), and the ultrasound indicators were closer to the normal population than the control group, thus confirming that the physiological function of the electroacupuncture group recovered faster. Zhao yiying et al. [23] examined the pelvic floor function recovery and urine leakage of patients in the two groups, which were treated by electroacupuncture combined with pelvic floor muscle training and pelvic floor muscle training alone by using pelvic

floor ultrasound regularly (before treatment and 6, 12, 18 weeks after treatment). They observed the BND, URA, RVA and urinary leakage of patients under pelvic floor ultrasound. According to the changes of LHA in three states of valsala, the therapeutic effect of electroacupuncture was evaluated. It was found that the BND, URA, RVA, and LHA at rest, anal retraction, and Valsalva action of the two groups after 6, 12, and 18 weeks of treatment were significantly lower than those of the same group before treatment. And the treatment group was significantly lower than that of the control group at the same period, the difference was statistically significant ($p<0.05$). This made it clear that electroacupuncture stimulation treatment could significantly improve the clinical symptoms and quality of life of SUI patients, with a longer duration of curative effect and better long-term therapeutic effect. Under the objective evaluation of pelvic floor ultrasound, it is further confirmed that electroacupuncture stimulation in previous studies can increase the elasticity and strength of pelvic floor muscles, reduce the relaxation state, and promote the coordinated movement of bladder detrusor and urethral sphincter.

4.2.5. Evaluation of curative effect of row acupuncture

Yu yongjin et al. [24] evaluated the clinical efficacy of row needle acupuncture in the treatment of female stress urinary incontinence by using transperineal three-dimensional pelvic floor ultrasound. It was found that row needle acupuncture combined with TCM syndrome differentiation and treatment in the treatment of female SUI clinical symptoms have been improved, especially in patients with mild to moderate SUI. After treatment, it was found that bladder neck mobility, bladder posterior horn, levator ani hiatus area, the distance between the lowest point of the bladder and the lower edge of the pubic symphysis, the formation rate of urethral infundibulum was lower than that before treatment ($p<0.05$). According to the changes of relevant parameters observed by pelvic floor ultrasound, it is further presumed that the mechanism of row needle acupuncture in the treatment of SUI may be related to improving the defects of bladder neck and urethral support structure, changing the pressure of urethra and bladder, etc. at the same time, pelvic floor ultrasound can objectively evaluate the therapeutic effect of row needle acupuncture in the treatment of female SUI.

4.2.6. Efficacy evaluation of floating acupuncture

Su Jinzhan et al. [25] observed the BND, RVA, UTA, URA, and whether the urethral opening was open under the maximum Valsalva action state with two-dimensional ultrasound, and measured LHAunder the maximum Valsalva action state with four-dimensional ultrasound. It was found that the BND, RVA, UTA, URA and LHA in the maximum Valsalva action state of patients, after floating needle treatment were significantly smaller than those in the control group (Kegel exercise) ($p<0.05$). And the proportion of funnel-shaped urethral orifice after floating acupuncture treatment was significantly reduced, which was statistically significant compared with the control group. It is concluded that pelvic floor ultrasound can directly, quantitatively and qualitatively assist in evaluating the pelvic floor functional status of patients with SUI treated by floating acupuncture, and clarify the curative effect of floating acupuncture in the treatment of SUI.

4.2.7. Efficacy evaluation of acupuncture combined with other treatment methods

Jianglijuan et al. [26] detected the posterior angle of bladder and urethra before and after treatment by PUVA(αAngle), trigone of bladder(βAngle), Urethral Tilt angle(γAngle), bladder neck vertical position(BNVP), BNVP of postpartum SUI patients treated by acupuncture combined with yiqishengti powder acupoint application α,β,γThe angles were decreased, and were significantly better than those in the control group (simple acupuncture). Thus, it is clear that the combination of acupuncture and Yiqi Shengti powder can play a greater therapeutic effect and effectively improve

the pelvic floor structure related ultrasound indicators (recoveryα,β,γAngle, improve bnvp), repair the damaged tissue of urethra in SUI patients, keep the position of urethral orifice and bladder neck stable, and promote the recovery of bladder function and pelvic floor muscle strength. Xiang xiuli et al. [27] found that the pelvic floor biofeedback stimulation alone was significantly lower than the combined acupuncture treatment ($p<0.05$), by comparing the LHA and RVA in the resting state and Valsalva state of pelvic floor biofeedback electrical stimulation alone. According to the evaluation of pelvic floor ultrasound, the effect of pelvic floor biofeedback electrical stimulation combined with acupuncture in the treatment of postpartum stress urinary incontinence is better than that of biofeedback electrical stimulation alone, which can effectively improve the pelvic floor muscle function of patients.

4.3. Basin ultrasound confirmed the superiority of acupuncture treatment

Wang Ping [28] observed and compared the therapeutic effects of electroacupuncture, warm acupuncture and thermosensitive moxibustion under three-dimensional pelvic floor ultrasound. It was found that the LHA, RVA, the distance from bladder neck to the lower edge of pubic symphysis in patients after electroacupuncture, warm acupuncture and thermosensitive moxibustion were better than those before treatment. The change of LHA in electroacupuncture group was better than that of warm acupuncture and thermosensitive moxibustion, and the changes of RVA and the distance from bladder neck to the lower edge of pubic symphysis in the electroacupuncture group and warm acupuncture group were better than those in the thermal moxibustion group (all $p<0.05$). It is concluded that the three groups have therapeutic effects on postpartum SUI, and electroacupuncture has the best effect. It can be seen that pelvic floor ultrasound can also evaluate the effectiveness of various acupuncture treatment methods.

5. Summary and Outlook

Although female stress urinary incontinence will not threaten the life safety of patients, it has brought some troubles to women's normal life and social interaction, which is called "social cancer" by people. In order to solve this embarrassing problem, early diagnosis and treatment must be carried out. Acupuncture and moxibustion, as a treatment method with obvious curative effect, little side effect and simple operation, is worth widely applying and popularizing in clinical practice. As a noninvasive, economical, simple and highly acceptable examination method, pelvic floor ultrasound plays an important role in the diagnosis and efficacy evaluation of SUI. Previous studies have also mostly confirmed that pelvic floor ultrasound images are highly consistent with gross anatomical images, providing reliable imaging support for the careful observation of female pelvic floor structures [29]. However, limited by the small sample size of the study, if the sample number is expanded, the results will have more reference significance. In order to further study the diagnosis and evaluation of pelvic floor ultrasound in acupuncture treatment of SUI, the next step is to expand the sample size, refine the measurement and comparison of various parameters, and further study and demonstrate the parameters and correlation. Therefore, in the future research of acupuncture and moxibustion treatment of this disease, doctors can use pelvic floor ultrasound as an examination method when conditions permit, so as to more intuitively and objectively evaluate the structural and functional status of patients' pelvic floor, so as to clarify the clinical efficacy of acupuncture and moxibustion treatment of SUI.

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