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Study on the application value of high intensity focused ultrasound in the treatment of gynecological diseases

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Abstract

Along with the advancement of science and technology and the ongoing development of adjuvant therapies, the treatment options for common or difficult diseases related to gynecology have become more diversified. At the same time, due to the increasing health awareness and the development of minimally invasive treatments, the majority of female patients are more in pursuit of swift and non-invasive treatments. For patients who are relatively poorly controlled by medication and fearful of surgical treatment, High-Intensity Focused Ultrasound (HIFU), also known as "HEFU", is a highly advantageous treatment for gynecological-related diseases. It is also publicly recognised in the West as a world-leading Chinese treatment technology. In recent years, there have been many reports on the use of the Heliport in the treatment of gynecology-related diseases, and its clinical efficacy has better clinical results and fewer adverse effects compared with traditional treatment methods.

Keywords: High-intensity focused ultrasound; Helio knife; uterine fibroids; adenomyosis; scar pregnancy; effectiveness.

Introduction

The High Intensity Focused Ultrasound (HIFU) tumor treatment system, known by its acronym, is a new and emerging treatment. As an emerging treatment, it has the advantages of non-invasiveness and quick recovery. It is now widely used in the treatment of tumors and gynecology-related diseases. The main principle of its action is to use high-intensity ultrasound focused on biological tissues to produce thermal effects, which are transformed into heat energy to achieve the purpose of "ablation", causing instant coagulation necrosis of the tissues in the focal area, but no significant damage and injury to the tissues outside the focal area [1], and the coagulated necrotic tissues can be gradually absorbed or scarified through body metabolism. The coagulated necrotic tissue can be metabolized by the body and gradually absorbed or scarred. This new technique for the local treatment of tumors, also known as thermal "excision", is mainly applicable to the treatment of malignant and benign solid tumors of tissues and organs [2].

As clinical development continues and the safety of the technology improves, the use of focused ultrasound is becoming more and more widespread, evolving from an adjunct to the treatment of tumor disease to a herbal treatment for clinically relevant oncological diseases. In the twenty-first century, this technology has also opened up new therapeutic areas, with positive effects on non-tumor diseases [3]. In this paper, we discuss the role and value of focused ultrasound technology in the treatment of gynecology-related diseases, with a view to providing important references for relevant clinicians in clinical diagnosis and treatment.

Specific applications of high-intensity focused ultrasound in gynecological diseases

Uterine fibroids

In recent years, with the popularization of primary and secondary prevention, as well as the progress of detection methods, and the influence of lifestyle and working environment, the incidence of uterine fibroids has been increasing year by year, mostly seen in women of reproductive age [4]. Depending on the site of growth, fibroids can be classified as cervical, sub mucosal, interstitial, or sub plasmalemmal fibroids. Depending on their number and site of growth, they are further classified as either solitary or multiple myomas. Also, as the disease progresses, the fibroids tend to degenerate. The enlarged or degenerated fibroids may cause menstrual disorders and increased vaginal discharge, as well as compression of local organs or tissues, resulting in discomfort [5]. The morphology of the uterine cavity can be altered by the fibroids, which can affect the development of fertilized eggs and cause serious complications such as infertility, which can seriously affect a woman's physical and mental health.

The conventional treatment of fibroids includes medication and surgery. Medication is mostly used to relieve symptoms and reduce the size of fibroids in preparation for further surgery. Surgery can be divided into open surgery and lumpectomy, depending on the type of surgery [6]. Traditional open surgery, although intuitive in its view, allows for rapid management of intra operative findings and allows for good removal of complex lesions, has a wide surgical reach, large incisions, long recovery time, and poor patient compliance. With lumpectomy, patient choice is higher and in recent years, with the development and maturity of technical means, adverse reactions have gradually diminished, with little impact on physical fitness and rapid patient recovery, but there are still corresponding risks, such as subcutaneous emphysema, ureteral injury, intestinal wall injury, large incisions, difficulty in lumpectomy suturing, postoperative bleeding and other adverse reactions, influenced by the operator's proficiency and the patient's constitution. These are all risks that have to be taken during the procedure.

The use of a High-Intensity Focused Ultrasound Knife (HEF), in the treatment of uterine fibroids, is the use of an emerging in vitro treatment, with the help of the physical characteristics of the HEF, while with the assistance of the instrument, to take visual treatment, the use of ultrasound probe the human body, the energy gathered in the focal area to be treated, through the cavitation and mechanical effect, accurate targeting lesions, ablation of lesions, this treatment method, only effective for the treatment of local This treatment method, which is only effective for local treatment, does not damage the surrounding healthy tissues, but only if the energy is too high or if the sound waves are deflected in the body during the transmission process, which may cause damage to the body [5]. Cai Dandan [7] used the Hepatome in combination with contracting to treat uterine fibroids. The preoperative and postoperative imaging examinations, showing the ablation rate, the extent of ablation, the comparison of the blood supply around the lesion, and the long-term follow-up showed that this treatment modality is effective and has a higher safety profile, low adverse effects, and good long-term therapeutic effects. Zhou Dan et al. used this method to treat uterine fibroids, and after the operation, found that the patient's related symptoms were significantly relieved, the time to resume voluntary exercise after the operation was shorter than that of traditional treatment, the quality of life was improved, and there was no effect on the normal physiological function of the ovaries, which has strong promotion value [8]. Studies have shown that the treatment frequency can be adjusted according to the size and extent of the lesion, usually set at around 1 MHz, with a stratified spacing of mostly 5 mm and a power of mostly 240-400 W [9]. As it is a local treatment, it has less impact on the endocrine function of the ovary, and there is no significant impact on the function of the Hypothalamic-Pituitary-Ovarian axis (HPO axis) in postoperative patients. Its mechanism of action does not affect the ovarian arteriovenous blood supply, so the body is less prone to stressful reactions and is safer [10].

Uterine adenomyosis

The base of the active endometrium penetrates the myometrium, resulting in high local hormone levels and consequently adenomyosis. However, the exact pathogenesis and cause of the lesion are not yet clear. However, some studies have shown that the development of this disease is related to hormone levels. When estrogen levels are elevated, the cells are prone to irregular changes under the influence of hormones, which affect the expression of endometrial and myometrial receptors and trigger the disease. The development of this condition can be influenced by frequent uterine operations, the mode of delivery, and breastfeeding [11]. The choice of relevant treatment modalities is determined by the size of the patient's lesions and the presence or absence of fertility requirements. Pharmacological treatment is aimed at reducing the size of the lesion and relieving clinical symptoms. Surgical treatment, with poorly defined lesion boundaries, makes complete removal of the lesion difficult and increases the risk of adverse pregnancy outcomes [12].

During treatment, patients need to be closely investigated and questioned about their previous health status, the bowel is prepared in advance, and the identified focal area is treated from point to line and line to surface to the target area under ultrasound localization according to the extent and severity of the lesion. The treatment power should not exceed 400 W, the treatment domain should not exceed 5mm, and the treatment frequency is less than 1 MHz, through the cavitation effect, so that the local temperature rises abruptly to 60-100 when the lesion undergoes coagulative necrosis, the ultrasound suggests the appearance of local echogenic enhancement or grayness increase as the standard of effective treatment when all treatment levels show the grayness increase suggests that the treatment can be ended [13], intra operative should be closely observed The patient's vital signs should be closely observed during the operation, and the operation should be stopped immediately if corresponding discomfort occurs. Jia [14] et al. used the Hepatome to treat adenomyosis, and after treatment, the lesion volume was reduced, the degree of dysmenorrhoea was relieved significantly, and physicochemical indices, such as hemoglobin concentration, also produced corresponding improvements, and the operation was safe with few adverse effects and no significant complications, proving that this method is safe and effective.

Scarred uterine pregnancy

The incidence of cesarean section and uterine fibroids is gradually increasing, and the number of operations on the uterus is also increasing, while abortion, curettage, and other operations on the uterus are also likely to cause damage to the uterus and poor recovery, resulting in the formation of a scarred uterus. The persistence of a scarred uterus has a major impact on the safety of another pregnancy, with a reduced ability of the uterus to contract and recover, predisposing it to complications such as uterine rupture and postpartum hemorrhage, as well as increasing the risk of scarred pregnancy [15]. The thin muscular layer of the uterine scar, which is affected by a pregnancy, softens the uterus and makes conventional uterine clearance prone to uterine rupture and uterine perforation.

The use of high-intensity focused ultrasound for the treatment of recurrent pregnancy in the scarred uterus can be re-visualized, with ultrasound waves passing through the moderately filled abdominal wall and bladder to accurately locate the site of the gestational sac, followed by the use of local thermal and cavitation effects to kill the gestational sac, causing apoptosis of trophoblast cells and a reduction in peripheral blood flow, while intra operative ultrasound equipment can be used to closely observe the patient's uterine blood perfusion changes in the situation, accurate coagulation, hemostasis and reduction of intraoperative bleeding. The specific treatment frequency, layer spacing, focal range, and treatment power should be set flexibly according to the size of the patient's gestational sac and the thickness of the muscular layer. In a clinical study by Wang Qiaoju [16]. using high-intensity focused ultrasound to treat scarred uterine pregnancies, it was found that patients had less postoperative bleeding, a faster drop in serum human chorionic gonadotropin (blood β-HCG), a shorter time to return to voluntary movement after surgery, higher efficiency and fewer adverse effects than with conventional uterine clearance. This method can be used alone or in combination with related therapeutic drugs or physical operations to enhance the therapeutic effect.

Cervical cancer

The treatment and prevention of cervical cancer by high-intensity focused ultrasound is mainly manifested in two ways: Firstly, to prevent and reduce the causes of cervical cancer. The second is the direct treatment of cancer foci. Cervical cancer is a type of neoplastic disease with a relatively clear cause. It is mainly manifested by persistent infection with the high-risk Human Papilloma Virus (HPV virus) of the cervix. There is a lack of definitive treatment for high-risk HPV viruses and the main focus is on enhancing local immunity. The advantages of using high-intensity focused ultrasound to treat high-risk HPV infection in cervical cancer are gradually becoming apparent. This technique has a significant therapeutic effect on the target area of the lesion, has little impact on normal tissue, is less invasive in terms of overall efficacy, and has no impact on reproductive function [17]. The specific operational reference is as follows: frequency setting range: 10 ± 2 MHz, pulse frequency: 1000 Hz, determined power range: 3-5 W/cm, 360° diffusion scanning around the ectocervix as a round point, stopping treatment when the ectocervix is slightly invaginated or when atrophy of the cervical hyperplastic tissue occurs after treatment. This method has good therapeutic potential with quick results, short treatment times, and high economic benefits [18].

In the early stages of cervical lesions, aggressive treatment is an important measure to prevent further deterioration of the cervical disease. The results of the study showed that patients with findings suggestive of Cervical Intraepithelial Neoplasia (CIN) grade I underwent a single session of focused ultrasound treatment, which resulted in reduced vaginal drainage, shorter drainage time, and faster wound healing after treatment. The operation involves continuous scanning and treatment circularly, with the ectocervix as a circular point, from the inside to the outside, layer by layer, at a speed of 5-10 mm/s. The scanning area is required to cover at least the lesioned area and the normal tissue within a range of no less than 2 mm from the outer edge of the lesioned tissue. During the follow-up period, immunohis to chemical examination of the patients revealed that this therapy increased the expression of tumor suppressor genes, decreased cell proliferation activity, further regulated the proliferation of relevant cells by decreasing the expression of P16 and Ki-67 in local cervical tissue, up regulated Fas expression and balanced apoptosis among cells, effectively promoting the normalization of cervical lesions [19].

High-intensity focused ultrasound, is important in assisting the diagnosis of cervical cancer and guiding, monitoring, and assessing the process and outcome of tumor treatment in real time [20]. The HEF, as an adjunct to cervical cancer treatment, is usually used in combination with chemotherapy and radiotherapy and is important in the treatment of cervical cancer lesions in patients with intermediate to advanced disease. During the treatment process, the treatment is usually performed in a multiple, progressive manner, with the approved treatment frequency varying according to the disease and scope. Changes in the patient's vital signs, according to the patient's condition determine the length and period of treatment [21].

Sclerosing vulvar lichen planus

Vulvar sclerosing Lichen Sclerosus (VLS) is a common inflammatory, non-tumourous lesion localized to the female vulva. The incidence has been increasing in recent years, but there is a lack of accurate and effective treatment. It is mainly degenerative atrophy of the local skin and mucosa of the vulva, which, if left untreated, can lead to loss of elasticity and failure to maintain the normal anatomical function of the local tissues. Conventional treatment includes topical medication, physiotherapy, and laser treatment. With the support of high technology, focused ultrasound can be applied in the treatment of vulvar sclerosing moss with remarkable results [22]. Based on not destroying normal tissues, the thermal effect formed by focused ultrasound is used to eliminate the local lesioned skin and subcutaneous tissues, promote local microcirculation, and achieve the purpose of relaxing the skin and relieving patients' symptoms. The latest guidelines state that this method is safe and effective when applied to patients who have unsatisfactory results from medication or have contraindications to relevant treatments. Experimental studies have shown that the treatment of rats with simple vulvar sclerosing moss using focused ultrasound inhibits dermal fibrosis and other cytokines related to the inhibition of dermal fibrosis by modulating Transforming Growth Factor Beta (TGF-β) and B-Cell Lymphoma-2 (Bcl-2). After active treatment, the degree of local recovery of the lesion was close to that of the normal group [23].

Summary and outlook

High-intensity focused ultrasound, in clinical application, has the advantages of good directionality, strong aggregation, and continuous propagation in an elastic medium, which causes a rapid increase in local temperature and physical denaturation

of the scorched domain tissue due to high temperature, playing a therapeutic role. In clinical practice, it has been widely used in various tumor diseases and proliferative pains and can play a positive therapeutic role on multiple organs and systems of the whole body. With the continuous development of relevant technology and further clinical research, focused ultrasound therapy will bring more patients to the gospel. In this paper, we hope to enhance the understanding of this therapy among more clinicians and patients and to provide references for subsequent related studies [24].

Declarations

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The data involved in our study were all derived from databases; therefore, our study did not require separate approval from the ethics committee.

Conflict of interest: No conflict of interest between the authors.

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