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EFFECTS OF MR-GUIDED AND ULTRASOUND-GUIDED FOCUSED ULTRASOUND TREATMENT FOR ADENOMYOSIS ON OVARIAN RESERVE ASSESSED BY ANTI-MÜLLERIAN HORMONE LEVELS: A NARRATIVE REVIEW

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ABSTRACT

Aim: This narrative review evaluates the current evidence on the impact of high-intensity focused ultrasound (HIFU), including MR-guided (MRgFUS) and ultrasound-guided (USgHIFU) techniques, on ovarian reserve in women treated for adenomyosis, with particular emphasis on anti-Müllerian hormone (AMH) level.
Methods: narrative review included evidence from prospective and retrospective studies, randomized trials, and original research in patients with adenomyosis, identified through searches of PubMed/MEDLINE, Embase, Web of Science, and Google Scholar.
Results: available studies consistently demonstrate that this treatment does not result in significant changes in AMH concentrations, irrespective of the method used, suggesting preservation of ovarian reserve.
Conclusion: In contrast to more invasive treatment options, such as uterine artery embolization or hysterectomy, HIFU acts locally, minimizing the risk of damage to ovarian tissue and vascular supply. This enables the preservation of fertility, which is particularly important for women desiring future childbearing. However, the available evidence is limited by small sample sizes, heterogeneous study populations, and short follow-up periods. Further large-scale, prospective studies with long-term follow-up are needed to confirm the sustained safety of HIFU and its impact on reproductive outcomes.

KEYWORDS

Adenomyosis, MRgFUS, USgHIFU, Anti-Müllerian Hormone, HIFU

CITATION

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Introduction

Adenomyosis is a benign disorder characterized by the presence of endometrial stroma and glands within the myometrium and is typically observed in reproductive-age women. This leads to diffuse enlargement of the uterus, and microscopically, ectopic (abnormally located) endometrial glands and stroma are visible, surrounded by hypertrophic smooth muscle cells. (Benagiano, Habiba, and Brosens, 2012; Santulli, Vannuccini, Bourdon, Chapron and Petraglia, 2025)

The main clinical manifestations include: chronic pelvic pain, infertility, and irregular menstrual cycles, abnormal uterine bleeding, dysmenorrhea. It should be noted that nearly one third of patients with adenomiosis are asymptomatic, which often results in the condition remaining undiagnosed. (Schrager, Yogendran, Marquez and Sadowski, 2022; Zhang, Li C, Li W, Xin, Qin, 2024)

Adenomyosis affects women of reproductive age; therefore, fertility-preserving treatment options are of particular importance. One of the modern, minimally invasive methods is magnetic resonance–guided focused ultrasound (MRgFUS) treatment. (Fan et al, 2012) This technology combines two advanced modalities: high-intensity focused ultrasound (HIFU) and magnetic resonance imaging (MRI). The integration of these methods enables precise focusing of energy, resulting in a temperature increase above 60 °C within a few seconds, which leads to protein denaturation and coagulative necrosis of the targeted tissue. Magnetic resonance imaging plays a crucial role in accurately localizing the lesion and monitoring intraprocedural temperature changes within the body in real time during the treatment. (Leporace et al, 2024) MRgFUS treatment involves the precise thermal ablation of adenomyotic tissue by concentrating ultrasound energy on a selected target area, with real-time monitoring using MRI. (Fan et al, 2012)

Another minimally invasive method is ultrasound-guided high-intensity focused ultrasound (USgHIFU). Similar to MRgFUS, it involves thermal ablation of adenomyotic lesions by focusing ultrasound energy on a selected target area; however, the procedure is performed under ultrasound guidance.

MRgFUS and USgHIFU are non-invasive, uterus-preserving methods that enable a significant reduction of adenomyosis-related symptoms, such as dysmenorrhea and menorrhagia, as well as a reduction in lesion volume. (Cai et al, 2023; Fan et al, 2012; Lee JS, Hong, Lee, Song and Kim, 2019)

Ovarian reserve is defined as the number of oocytes remaining within the ovary. This number is highest during fetal life and gradually declines with age as a result of ovulation and the natural process of follicular atresia, ultimately leading to complete depletion at menopause. Anti-Müllerian hormone (AMH) is secreted by the granulosa cells of small growing ovarian follicles, from the primary follicle stage to the small antral follicle stage. As the number of growing follicles reflects the pool of resting follicles, serum AMH concentration is currently regarded as the best indirect marker of the quantitative component of ovarian reserve. In contrast to hormones such as FSH or estradiol, AMH levels are independent of the menstrual cycle, allowing assessment to be performed on any day of the cycle. (Practice Committee of the American Society for Reproductive Medicine, 2020; Moolhuijsen and Visser, 2020) As a marker of ovarian reserve, AMH may be a useful parameter for evaluating the safety of conservative treatment methods for adenomyosis.

Aim of the publication

The purpose of this study was to explore the impact of MRgFUS and USgHIFU treatment on ovarian reserve as reflected by anti-Müllerian hormone levels.

Methodology

This study was conducted as a narrative review based on evidence from prospective cohort studies, retrospective studies, retrospective cohort studies, original research articles, narrative reviews, and randomized studies involving patients with adenomyosis. Databases searched included PubMed/MEDLINE, Embase, Web of Science, and Google Scholar. Search terms included: “Adenomyosis,” “High-intensity focused ultrasound (HIFU),” “Ultrasound-guided high-intensity focused ultrasound (USgHIFU),” “Magnetic resonance-guided high-intensity focused ultrasound (MR-HIFU / MRgFUS),” “Anti-Müllerian hormone (AMH),” “Ovarian reserve”. Analysis techniques include study selection, data extraction, qualitatively summarizing and interpreting findings across different studies.

Results

In a group of 74 premenopausal women aged 24–48 years with AMH levels ≥0.1 μg/L, no significant changes in AMH were observed after MRgFUS treatment. The median AMH level before the procedure was 1.20 μg/L and 1.23 μg/L three months after treatment ($p = 0.90$). Neither the location of the treated lesion (anterior wall, posterior wall, or uterine fundus) nor the total energy delivered during the procedure correlated with changes in ovarian reserve. (Otonkoski et al, 2023)

Another study conducted by Keserci and Duc provides further evidence supporting the safety of the MRgFUS method. Patients were divided into two groups according to the degree of ablation achieved, measured as the non-perfused volume ratio (NPVr): Group A with NPVr ≥ 90% and Group B with NPVr < 90%. The mean AMH concentration before treatment in Group A was 1.98 ± 1.15 ng/mL and remained unchanged at 6 months after the procedure (1.98 ± 1.15 ng/mL; $p = 0.327$). In Group B, the concentration changed from 1.65 ± 0.94 ng/mL to 1.65 ± 0.95 ng/mL ($p = 0.160$). Thus, the degree of ablation of the pathological lesion had no effect on AMH levels. Even when a very high rate of diseased tissue ablation was achieved, the ovaries were not adversely affected, and the impact on ovarian reserve was negligible. Furthermore, the study confirmed the clinical effectiveness of the method, demonstrated by a reduction in lesion volume and improvement in symptoms. (Keserci and Duc, 2018)

Another study assessed AMH levels as a marker of ovarian reserve following ultrasound-guided high-intensity focused ultrasound thermoablation in women with uterine fibroids and adenomyosis. The study included 79 women (45 with uterine fibroids and 34 with adenomyosis) aged 24–45 years. The mean AMH level was 2.11 ± 2.66 μg/L before treatment and 1.84 ± 2.57 μg/L at 6 months after the procedure. Statistical analysis demonstrated no significant difference between pre-treatment and 6-month AMH levels ($P > 0.05$). (Lee JS, Hong, Lee KH and Kim, 2017)

The study by Wei et al. focused on the evaluation of symptom improvement and obstetric outcomes in patients with different types of adenomyosis treated with HIFU. The study included 129 infertile women with adenomyosis who were planning pregnancy. Consistent with previous studies, the safety of HIFU with respect to ovarian function was confirmed. No statistically significant differences in AMH levels were observed before the procedure and 6 months after treatment in any of the groups. Moreover, the overall post-treatment pregnancy rate was 38.8% (50 of 129 patients); however, the outcomes differed significantly depending on the type of disease. (Wei et al, 2023)

Discussion

This narrative review summarizes the current evidence on the potential impact of HIFU treatment on ovarian reserve, with particular emphasis on anti-Müllerian hormone levels. Overall, the available data suggest that MRgFUS and USgHIFU do not significantly impair ovarian reserve, as assessed by AMH levels, in women undergoing treatment for adenomyosis.

Unlike other treatment options for adenomyosis, such as uterine artery embolization (UAE), in which embolic material may reach the ovarian circulation, or hysterectomy, which may adversely affect ovarian perfusion, these techniques exert their effect exclusively at the local level. Available evidence suggests that the ovaries and their blood vessels remain outside the treatment area, thereby minimizing the risk of thermal injury. In the case of MRgFUS, the possibility of real-time temperature monitoring constitutes an additional safety feature. (Lee JS, Hong, Lee KH and Kim, 2017; Otonkoski et al, 2023)

The study by Keserci (Keserci and Duc, 2018) showed that achieving an NPVr of ≥ 90%, regarded as a marker of clinical success, was not associated with an increased risk of ovarian damage. These findings suggest that treatment can be directed toward complete ablation of the lesions in order to achieve symptom relief without adversely affecting ovarian reserve.

Differences in technology and monitoring

MRgFUS uses magnetic resonance imaging, which provides excellent soft-tissue contrast and three-dimensional visualization, thereby facilitating treatment planning and patient selection. In contrast, USgHIFU is based on real-time ultrasonographic guidance. A key advantage of MRgFUS is the ability to perform real-time MR thermometry, which allows precise monitoring of temperature elevation within the target tissue. (Keserci and Duc, 2018; Otonkoski et al, 2023) In USgHIFU, by comparison, the operator relies on grayscale changes in the ultrasound image. (Wei et al, 2023) Therefore, this technique requires greater operator experience, which may also contribute to lower procedural precision.

Clinical efficacy and procedure duration

However, AMH alone does not fully capture the overall clinical value of treatment. Symptom relief, reduction in lesion volume, and post-treatment pregnancy outcomes should also be taken into account when evaluating the role of conservative therapies for adenomyosis.

Both methods have demonstrated effectiveness in reducing lesion volume. In studies of USgHIFU, adenomyosis volume reductions of approximately 50–54% have been reported at 6–12 months. (Bahutair and Alhubaishi, 2024; Lee JS, Hong, Lee KH and Kim, 2017) In the case of MRgFUS, a mean lesion volume reduction of approximately 34% at 6 months has been observed when a high ablation rate (NPVr ≥ 90%) is achieved. (Keserci and Duc, 2018)

Available data also suggest that USgHIFU procedures may be shorter than MRgFUS procedures, with mean treatment times of 73.5 and 115.3 minutes, respectively, although procedure duration depends on lesion size and the energy delivered. (Keserci and Duc, 2018; Lee JS, Hong, Lee KH and Kim, 2017)

MRgFUS provides greater imaging precision and thermal safety through real-time MR thermometry, whereas USgHIFU is more commonly reported in the literature as an effective treatment option and may be faster to perform. (Bahutair and Alhubaishi, 2024)

The Symptom Severity Score (SSS) decreases markedly within 3 to 12 months after the procedure, from 61.57 to 27.64 at 6 months. Long-term follow-up has demonstrated a sustained reduction in symptom burden of nearly 58% at 12 months. (Lee JS, Hong, Lee KH and Kim, 2017) HIFU effectively relieves dysmenorrhea across all types of adenomyosis, with mean pain scores declining significantly as early as the first month after treatment. At 12 months, pain is minimal or absent in most patients, with median pain scores decreasing from 4.0–8.0 to 0.0–1.0. Quality of life also improves significantly following treatment. (Bahutair and Alhubaishi, 2024; Wei et al, 2023)

The treatment enables rapid control of excessive menstrual bleeding. In all patients with menorrhagia, menstrual blood loss returned to normal within 3 months after the procedure. This reduction in bleeding is likely attributable to elimination of ectopic endometrial tissue within the myometrium and a reduction in endometrial surface area. (Wei et al, 2023)

Overall, HIFU appears to be a highly effective non-invasive treatment modality, providing sustained relief of pain and bleeding as well as significant improvement in quality of life, with optimal outcomes achieved when the ablation area is maximized. (Keserci and Duc, 2018; Lee JS, Hong, Lee KH and Kim, 2017; Wei et al, 2023)

Fertility outcomes

Another important consideration is the potential effect of HIFU therapy on fertility outcomes. The issue of reproductive potential and the likelihood of achieving pregnancy after HIFU is one of the strongest arguments in favor of this treatment in women of reproductive age. Unlike traditional surgical methods, such as adenomyomectomy or hysterectomy, HIFU preserves uterine integrity and avoids surgical scarring, which is of key importance for the course of future pregnancy. (Bahutair and Alhubaishi, 2024; Wei et al, 2023)

The overall pregnancy rate after HIFU for adenomyosis is approximately 38.8%, with rates as high as 52% reported in cases of focal adenomyosis. Because the procedure is non-invasive, women may attempt conception much sooner than after conventional surgery. Although the median time to pregnancy reported in available studies was approximately 5–6 months, the lack of a prolonged healing period associated with surgical incision is a major advantage, particularly for patients in whom age is an important factor. (Bahutair and Alhubaishi, 2024; Wei et al, 2023)

Importantly, HIFU may also reduce the risk of uterine rupture during pregnancy and childbirth, as it does not disrupt myometrial continuity to the same extent as surgical treatment. (Bahutair and Alhubaishi, 2024; Lee JS, Hong, Lee KH and Kim, 2017; Wei et al, 2023)

In a large population-based study the rate of hysterectomy among women aged 16–45 with newly diagnosed adenomyosis was 79.0% within five years of diagnosis. (Yu et al, 2020) This constitutes a significant proportion of women of reproductive age suffering from adenomyosis. MRgFUS and USgHIFU represents an attractive, non-invasive alternative to surgical management, particularly for patients who wish to preserve fertility.

Limitations and future research directions

One important limitation is the small number of available studies. Furthermore, two of the cited studies (Otonkoski et al, 2023; Lee JS, Hong, Lee KH and Kim, 2017) - included not only patients with adenomyosis, but also women with uterine fibroids. Although the results were consistent, the adenomyosis subgroups in both studies were smaller than the fibroid subgroups, and the outcomes were not reported separately. These findings underscore the need for further studies in larger, more homogeneous populations of women with adenomyosis. Appropriate stratification of study groups according to age, as well as the type and severity of adenomyosis, should also be considered.

Another limitation is the relatively short follow-up period, typically ranging from 3 to 6 months. Although AMH appears to remain stable during this interval, long-term data extending beyond 2 years are still lacking and should be a focus of future research. Further prospective studies with larger cohorts and longer follow-up are needed to determine whether the apparent stability of AMH after treatment translates into preserved long-term fertility outcomes.

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