Magnetic Resonance Imaging-Guided Focused Ultrasound Surgery for Patients with Multiple Leiomyomas and/or Huge Leiomyoma

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Abstract

The combination of accurate guidance of MRI and the thermal ablation of focused ultrasound transducer produces a completely innovative and non-invasive method for eradicating leiomyoma. In this work, we aimed to display an alternative role of this method for cases of multiple leiomyomas and/or huge leiomyoma with efficacious outcomes along with short communication about the pros and cons of these findings.

Keywords: Multiple Leiomyomas; Huge Leiomyoma; Focused Ultrasound Surgery; Non-Invasive Treatment

Abbreviations: MRI: Magnetic Resonance Imaging; FUS: Focused Ultrasound Surgery

Introduction

Uterine fibroids (known as leiomyoma) which disrupt the functions of the uterus and cause menorrhagia, dysmenorrhea, anemia, pelvic pressure or pain, urinary incontinence, recurrent pregnancy loss and infertility represent the most common tumor in women. The lifetime prevalence of fibroids is more than 80% among black women and about 70% among white women [1]. Patients with symptomatic multiple leiomyomas and huge leiomyoma desired to conserve the uterus for further delivery birth which generated one of the most common problematic medical conditions which have gynecologist needed to be considered and find the appropriate treatments cautiously. Magnetic Resonance Imaging (MRI)-guided Focused Ultrasound Surgery (FUS) which combines the anatomical and functional imaging of MR with the thermal ablation possibilities of FUS, is an alternative treatment to hysterectomy for the treatment of uterine fibroids and preserves the uterus [2,3]. In this short communication, we aimed to display one tough case of 15 leiomyomas and another tough case of huge leiomyoma ablated profitably by FUS along with the pros and cons of these findings.

Results

A nulliparous 30-year-old patient with history of uterine leiomyoma complained bulk effect of pelvis admitted to department of gynecology. MRI examination revealed that there were 15 uterine leiomyomas affected almost areas of anteverted uterus considered as all type II uterine leiomyomas (the signal intensity of leiomyoma was greater than that of skeletal muscle and less than that of myometrium) (Figure 1A) [2]. The perfusion classification of uterine leiomyomas was regarded as type A uterine leiomyoma (the time signal intensity curve of uterine leiomyoma was less than that of myometrium) (Figure 1B) [3]. The patient was indicated single phase focused ultrasound surgery under the guidance of magnetic resonance imaging by which clinician utilized 40 treatment cells (12mm, n = 12; 14mm, n = 18; 16mm, n = 10) and a mean power of 158 ± 26W. After 144 minutes of treatment duration, a mean non-perfused volume ratio of all leiomyomas was 98% (Figure 1C). At 24-hour posttreatment, patient was discharged without adverse events. At 6 months of follow-up, all leiomyomas were shrinked with total mean volume reduction ratio of 52% and the pelvic tension symptom was resolved entirely (Figure 1D). In addition, anti-mullerian hormone level prior to ablation and after 6 months of follow-up was preserved comprehensively at the level of 3.71ng/mL [4].

A nulliparous 28-year-old patient with history of leiomyoma suffered from urinary retention and pelvic pressure admitted to department of gynecology. On the physical examination, clinician found a big palpable mass on the pelvis. On T2-weighted image, there was an intramural leiomyoma located on the anterior wall of retroverted uterus with diameter of 151mm considered as a type II leiomyoma (the signal intensity of leiomyoma was higher than that of skeletal muscle and lower than that of myometrium) (Figure 2A) [2]. On perfusion weighted image, leiomyoma was regarded as a type A leiomyoma (the time signal intensity curve of leiomyoma
was lower than that of myometrium) (Figure 2B) [3]. The patient desired to undergo focused ultrasound surgery instead of open surgery. The focused ultrasound surgery under the guidance of magnetic resonance imaging exploited 52 treatment cells (12mm, n = 8; 14mm, n = 23; 16mm, n = 21) placed with one layer strategy, and a mean power of 150 ± 22W yielded a non-perfused volume ratio of 91% (Figure 2C) with a total treatment time of 232 minutes. At 12-hour postablation, patient was discharged without side effects. At 6-month follow-up, the diameter of leiomyoma was reduced to 82mm and the complaint symptoms were resolved completely (Figure 2D). In addition, serum anti-mullerian concentration of this case prior to ablation and after 6 months of treatment was preserved entirely at the level of 3.21ng/mL [4].

Discussion

FUS was depended on the biological thermal principle of high intensity focused ultrasound on the targeted spot to lift the tissues’ temperature up to the threshold of coagulative necrosis and protein denaturation (Figure 3) [2,3]. In a recent study by He et al, the findings revealed that FUS was very effective in eradicating multiple leiomyomas of black women. In their study, the median number of

Figure 1: (A) Sagittal T2-weighted image at screening phase shows multiple uterine leiomyomas. (B) Axial perfusion-weighted image at screening phase shows the time signal intensity curve of uterine leiomyoma lower than that of myometrium. (C) Coronal contrast enhancement T1-weighted image after treatment shows near-complete ablation of all uterine leiomyomas. (D) Sagittal T2-weighted image at 6-month follow-up shows significant shrinkage of all uterine leiomyomas.

Figure 2: (A) Sagittal T2-weighted image at screening phase shows a huge uterine leiomyoma. (B) Axial perfusion-weighted image at screening phase shows the time signal intensity curve of uterine leiomyoma lower than that of myometrium. (C) Coronal contrast enhancement T1-weighted image after treatment shows near-complete ablation of uterine leiomyoma. (D) Sagittal T2-weighted image at 6-month follow-up shows significant shrinkage of uterine leiomyoma.
uterine fibroids was 6 (3-9). The median non-perfused volume ratio was 85.2% with overall mean treatment time 97.3 min ± 61.3 (40-240) [5]. No major complications occurred during and after FUS treatment. At 6-month follow-up, the overall mean shrinkage of 21 cases was about 52.5% ± 36.3. In this study, we also performed single phase FUS flourishingly on patient with 15 leiomyomas without major adverse events fully agreement with previous study [5]. In this study, we utilized "one layer strategy" treatment cells by which the heat accumulation in the nearfield of the focal plane can be taken advantage to ablate the huge leiomyoma with diameter ≥ 150mm. The plane for putting treatment cells was positioned at the anterior two thirds of the tumors (Figure 4). The heat accumulation in the anterior part of tumors can enhance the treatment speed which will reduce the risk of deep vein thrombosis owing to long treatment time in prone position. In addition, this strategy ensures that two thirds of the tumor automatically necrosis because of gradual heat accumulation phenomenon during the sonication procedure (Figure 5). The effectiveness of placing the treatment cells on the same plane for eradicating uterine fibroids with mean diameter ≥ 110mm was demonstrated in two previous studies [6,7].

Figure 3: The temperature map images show (A) coronal plane, (B) sagittal plane, (C) near-field, and (D) far-field.

Figure 4: T2W images show one layer strategy with all treatment cells placed in the same (A) coronal plane and (B) axial plane. The center of the overlapped sonication area (C) manifests the gradual heat accumulation phenomenon.
Nonetheless, a recent study found acute kidney damage due to tumor lysis statement after FUS treatment on a 140mm diameter uterine fibroid [8]. Therefore, in case of too large uterine fibroids, clinicians should consider to reduce the tumor diameter prior to FUS treatment to ensure patient safety profile and improve ablation efficacy. It is concluded that size of uterine fibroids can differ from small tumor localized on the uterus to huge tumor conquered the whole abdominal cavity. Uterine fibroids are relied on estrogen to maintain and develop. One of the medications in treatment strategy is to reduce the concentration of serum estrogen. Gonadotropin-releasing hormone agonist (GnRH agonist) is indicated in treatment of uterine fibroids by producing the hypo estrogen statement to inhibit the development of tumors. It is concluded that the mean volume reduction of uterine fibroids was 36% after indication of 3-month GnRH agonist for the uterine fibroid diameter ≥ 10cm, (Figure 6) [9]. In another study, uterine fibroid volume and perfusion are alleviated after utilizing 3-month GnRH agonist so that uterine fibroid tissue is more adapted to the FUS ablation [10]. During the treatment process, utilizing continuously intravenous infusion oxytocin (0.1 U/min) can promote the mild contraction of the myometrium which limits the amount of blood to the uterus contributed to the efficiently cumulative heat at the targeted tissue during ablation procedure. Thus, it enhances the treatment speed and ablation efficacy in case of large uterine fibroids. It is also concluded that after the use of oxytocin, the wash-in rate and maximum signal intensity of uterine fibroids was significantly attenuated; simultaneously, time-to-peak and mean transit time of uterine fibroids were significantly perpetuated [11]. Hence, intravenous infusion of oxytocin can reduce significantly not only the average sonication energy but also the sonication time to attain 60 °C for a focused point. Furthermore, the sonication energy to elevate tissue temperature 1 °C is significant lower than without utilizing infusion of oxytocin. As a result, oxytocin could significantly reduce the mean power during the ablation procedure, enhance the treatment speed and ablation efficacy in case of large uterine fibroids [12].
**Conclusion**

Based on the findings in this study, FUS treatment should be regarded as an alternatively innovative treatment for patients with multiple leiomyomas and/or huge leiomyoma. Nevertheless, clinicians should optimize the treatment strategy in case of huge leiomyoma and multiple leiomyomas for ensuring the safety of patients. Further studies will be crucial to validate the efficacy and safety of FUS on the large population of patients with multiple leiomyomas and huge leiomyoma.

**Disclosure statement**

Informed consent to all patients in this article was obtained. Nguyen Minh Duc and Pham Hong Duc contributed equally to this article. All authors read and approved manuscript. The authors of this manuscript declare no conflict of interest.

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