Lipus in Obstetrics and Gynaecology

Kalaimagal. M
Professor cum Principal, Sandhya college of nursing, Nandiyalam, Ranipet DT- 632517, Tamil Nadu, India

***Abstract*—Over the past decade, ultrasound therapy in obstetrics and gynecology has advanced considerably. While high-intensity ultrasound is widely established in clinical practice, low-intensity ultrasound is emerging as a promising modality, transitioning from preclinical research to clinical application. Low-intensity pulsed ultrasound (LIPUS) is a non-invasive technique that delivers low-intensity pulsed wave stimulation and primarily exerts its effects through non-thermal mechanisms, offering a safe, cost-effective, and convenient therapeutic approach.**

LIPUS induces cellular responses by converting mechanical energy into biochemical signals via mechanisms such as cavitation, acoustic streaming, and mechanical stimulation. These processes regulate molecular pathways and influence various biological activities.

This study reviews the biological mechanisms underlying LIPUS and its therapeutic applications in obstetric and gynecological diseases, aiming to support its precise clinical use and provide a theoretical foundation for its broader implementation in this field.

***Index Terms*—Low-intensity pulsed ultrasound (LIPUS),non-invasive therapy, cavitation, acoustic streaming, mechanical stimulation, molecular mechanisms, clinical applications**

I. INTRODUCTION

Low-Intensity Pulsed Ultrasound (LIPUS) in obstetrics and gynecology (OBG) shows promising biological and biodynamic effects, including enhanced tissue repair, reduced inflammation, improved vascularization, and potential applications in reproductive health and pregnancy-related conditions. It is being explored for infertility treatment, endometrial receptivity, pelvic healing, and pregnancy complications. Research highlights its ability to stimulate cellular signalling without harmful thermal effects, making it a safe adjunct therapy.

LIPUS is a type of medium-frequency ultrasound (0.7-3 MHz) that is pulsed in wave mode (100 and 1,000 Hz) and delivered at an intensity (<3 W/cm2) much lower than traditional ultrasound energy. Most piezoelectric transducers on the market are made of ceramic materials that can convert input electrical energy into mechanical energy (ultrasound waves). When the ultrasound beam is emitted from the therapeutic ultrasound device's treatment head, the energy distribution in space within the beam is non-uniform. The ultrasound beam closest to the treatment head is called the near field, where the ultrasound energy is higher and varies significantly locally, making it more commonly used in LIPUS therapy applications. The length of the near field is influenced by the transducer radius, speed of sound in the medium, and frequency, which allows for changes in the size and shape of ultrasound transducers to meet the treatment needs of different parts

II. BIOLOGICAL EFFECTS IN OBG

- ✓ Cellular Mechan transduction
- ✓ LIPUS activates integrins and ion channels, triggering pathways like MAPK and PI3K/Akt.
- ✓ Promotes expression of growth factors (VEGF, BMPs, IGF) crucial for uterine and ovarian tissue repair.
- ✓ Anti-inflammatory Action
- ✓ Downregulates pro-inflammatory cytokines (IL-1β, TNF-α).
- ✓ Reduces oxidative stress in reproductive tissues, supporting healthier implantation environments.
- ✓ Angiogenesis & Vascular Health
- ✓ Stimulates endothelial cell proliferation and vascular remodelling.
- ✓ May improve uterine blood flow, beneficial in cases of infertility linked to poor endometrial receptivity.

Biodynamic Effects in Human Reproductive Tissues
Mechanical Micro-vibrations

- Enhance nutrient transport and cellular metabolism in uterine and ovarian tissues.
- Improve fluid dynamics in pelvic structures, supporting tissue regeneration.

Tissue-Level Outcomes

- Endometrium: Improved receptivity for embryo implantation.
- Ovaries: Potential support for follicular development and recovery after surgical interventions.
- Pelvic Floor & Uterus: Accelerated healing post-surgery (e.g., cesarean section, myomectomy).
- Pregnancy: Investigated for reducing complications like intrauterine growth restriction (IUGR).

Fertility-Related Applications
1. IVF Support
Biological Effects

- Enhances endometrial receptivity by stimulating VEGF and IGF expression.
- Promotes angiogenesis, improving uterine blood flow for implantation.

Biodynamic Effects

- Micro-vibrations improve nutrient transport and cellular metabolism in the endometrium.

Clinical Potential

- Could increase implantation rates in IVF cycles.
- May reduce the need for repeated embryo transfers.

2. Ovarian Stimulation & Function
Biological Effects

- Reduces oxidative stress in ovarian tissue.
- Supports follicular development via improved microcirculation.

Biodynamic Effects

- Mechanical stimulation enhances fluid dynamics around follicles.

Clinical Potential

- May aid women with poor ovarian reserve or post-surgical ovarian recovery.
- Could complement hormonal stimulation protocols.

3. Endometrial Repair
Biological Effects

- Stimulates cell proliferation and extracellular matrix remodelling.

Biodynamic Effects

- Improves tissue healing after procedures like curettage or hysteroscopy.

Clinical Potential

- Useful in cases of thin endometrium or Asherman's syndrome.

Pregnancy-Related Uses
1. Placental Health
Biological Effects

- Promotes angiogenesis and vascular remodelling in the placenta.
- Reduces inflammatory cytokines, supporting maternal-fetal exchange.
- It is a safe and effective method for treating postpartum uterine involution.

Biodynamic Effects

- Improves microcirculation and nutrient delivery.
- Postpartum Urinary Retention by inducing the contraction of bladder smooth muscle.

Clinical Potential

- Investigated for intrauterine growth restriction (IUGR).
- Could enhance fetal growth outcomes.
- The mechanical effect of ultrasound can produce mechanical stimulation, and the uterine smooth muscle tissue is very sensitive to a certain frequency of mechanical stimulation and can produce contraction can promote postpartum uterine involution

2. Cesarean Section Recovery
Biological Effects

- Stimulates fibroblast activity and collagen synthesis.
- Reduces inflammation at the wound site.

Biodynamic Effects

- ❖ Mechanical stimulation accelerates scar remodelling.

Clinical Potential

- ❖ Faster wound healing, reduced adhesions, and improved cosmetic outcomes.

3. Pelvic Floor Repair

Biological Effects

- ❖ Enhances muscle regeneration and reduces inflammatory damage.

Biodynamic Effects

- ❖ Improves circulation and tissue elasticity.

Clinical Potential

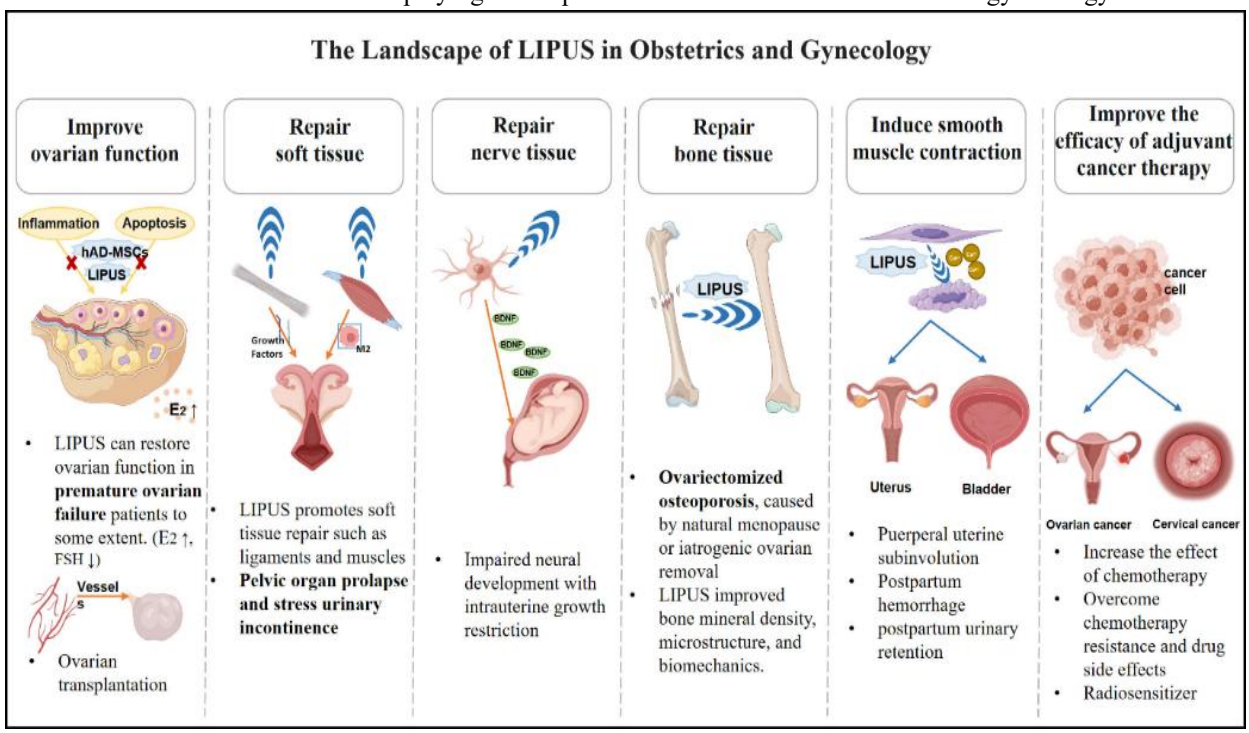
- ❖ Could support recovery after childbirth-related injuries or prolapse surgery.

Gynaecological related uses

Efficacy of cancer chemotherapy and radiotherapy

- ❖ LIPUS plays an increasingly clear role in the treatment of cancer, and has also attracted great attention in gynecological cancer.
- ❖ Existing studies mainly focus on ovarian cancer and cervical cancer. The combination of S-phase blocking drugs with LIPUS may increase the efficacy of chemotherapy in treating cervical cancer and also be used as a sensitizer for radiotherapy

The overview of LIPUS playing a therapeutic role in the field of obstetrics and gynecology.



III. CONCLUSION

Low-intensity pulsed ultrasound (LIPUS) is a specific type of ultrasound that delivers at a low intensity and outputs in the mode of pulsed waves. It has minimal thermal effects while maintaining the transmission of acoustic energy to the target tissue, which is able to provide non-invasive physical stimulation for therapeutic applications. Additionally, research has shown that LIPUS is a promising modality for neuromodulation

REFERENCES

[1] Zhou, Y., Wang, J., Li, X. et al. (2019) 'Low-intensity pulsed ultrasound promotes endometrial regeneration and improves pregnancy outcomes', Reproductive Sciences, 26(11), pp. 1453–1463.

[2] Wang, Y., Chen, X., Cao, W. and Shi, Y. (2020) 'Low-intensity pulsed ultrasound enhances endometrial receptivity via angiogenesis and growth factor expression', Ultrasound in Medicine & Biology, 46(7), pp. 1783–1792.

[3] Hu, L., Zhao, X., Liu, J. et al. (2021) 'Therapeutic effects of low-intensity pulsed ultrasound on thin endometrium', Journal of Ultrasound in Medicine, 40(2), pp. 351–360.
[4] Zhang, Y., Li, J., Chen, Y. et al. (2018) 'Effects of low-intensity pulsed ultrasound on ovarian function and follicular development', BioMed Research International, 2018, pp. 1–8.
[5] Li, Y., Wang, S., Chen, J. et al. (2020) 'Low-intensity pulsed ultrasound improves ovarian reserve and function in animal models', Theriogenology, 150, pp. 287–295.
[6] Gao, F., Zhang, Y., Wang, S. et al. (2019) 'LIPUS promotes angiogenesis and tissue repair in reproductive organs', Experimental and Therapeutic Medicine, 18(6), pp. 4567–4574.
[7] Qin, J., Liu, X., Sheng, X., Wang, H. and Gao, S. (2016) 'Assisted reproductive technology and adverse pregnancy outcomes: implications for therapeutic modalities', Fertility and Sterility, 105(1), pp. 73–85.
[8] Takeuchi, S. et al. (2017) 'Application of low-intensity pulsed ultrasound in gynecological tissue healing: experimental insights', Ultrasound in Obstetrics & Gynecology, 50(4), pp. 456–462.
[9] Chen, L. et al. (2021) 'Low-intensity pulsed ultrasound improves uterine repair after injury', American Journal of Translational Research, 13(5), pp. 4562–4571.
[10] Sun, H. et al. (2020) 'Effect of ultrasound stimulation on endometrial stem cells and regeneration', Stem Cell Research & Therapy, 11, p. 537.