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MATHEMATICAL MODELING OF THE PATHOGENESIS OF ENDOMETRIAL POLYPS IN ENDOCRINE, HEPATOBILIARY, AND THYROID DISORDERS

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ABSTRACT

Endometrial polyps are a common pathology of the endometrium, accompanied by abnormal uterine bleeding and impaired reproductive function. In recent years, increasing attention has been paid to the role of systemic disorders — endocrine, hepatobiliary, and thyroid. The combination of polycystic ovary syndrome, non-alcoholic fatty liver disease, and hypothyroidism forms a state of chronic hyperestrogenism and stimulates pathological proliferation of the endometrium. The aim of the article is to provide a comparative review of current data on the role of endocrine, hepatobiliary, and thyroid disorders in the pathogenesis of endometrial polyps, as well as an analysis of the prospects of mathematical modeling.

Keywords: Endometrial polyps, PCOS, NAFLD, hypothyroidism, hormonal imbalance, hyperestrogenism, mathematical modeling.

INTRODUCTION

Endometrial polyps are diagnosed in 24–31% of women of reproductive age and up to 15% in postmenopause. They are associated with a risk of malignancy and infertility. In recent years, researchers increasingly emphasize the role of endocrine, hepatobiliary, and thyroid disorders. PCOS leads to chronic anovulation and hyperestrogenism, NAFLD reduces estrogen metabolism in the liver, and hypothyroidism increases TSH and prolactin levels, further aggravating hormonal imbalance. Mathematical modeling makes it possible to combine these factors into a single system, forming a basis for risk prediction and personalized therapy.

PURPOSE OF THE WORK

A comparative review of modern data on the role of endocrine, hepatobiliary, and thyroid disorders in the pathogenesis of endometrial polyps, as well as an analysis of the prospects of mathematical modeling.

RELEVANCE

Endometrial polyps are diagnosed in 24–31% of women of reproductive age and up to 15% in postmenopause. They are associated with a risk of malignancy and infertility. In recent years, researchers have emphasized the importance of endocrine, hepatobiliary, and thyroid disorders in the pathogenesis of the disease. The absence of comprehensive models combining these factors necessitates the development of new approaches, including mathematical modeling.

LITERATURE REVIEW

Endocrine disorders (PCOS) are characterized by hyperinsulinemia, hyperandrogenism, and prolonged stimulation of the endometrium by estrogens without adequate progesterone protection. This significantly increases the risk of hyperplasia and polyp formation (Legro et al., 2013).

Hepatobiliary disorders, especially NAFLD, impair estrogen inactivation in the liver. Yang et al. (2018) showed that patients with NAFLD had higher circulating estrogen levels compared to healthy women, which correlated with an increase in endometrial thickness. Thyroid disorders: hypothyroidism reduces estrogen clearance and causes hyperprolactinemia, while hyperthyroidism disrupts the cycle due to luteal phase deficiency. According to Poppe & Velkeniers (2004), up to 20% of women with hypothyroidism experience significant menstrual irregularities.

Thus, the combination of endocrine, hepatobiliary, and thyroid pathologies exerts a synergistic effect, increasing the risk of polypogenesis.

Materials and Methods

A literature analysis was conducted using PubMed, Scopus, and Web of Science databases (2000–2025), focusing on endometrial polyps, PCOS, NAFLD, and thyroid disorders. Twenty of the most cited studies were selected, including clinical studies, meta-analyses, and mathematical models. The review included data on hormonal profile, liver function, thyroid status indicators, and echographic characteristics of polyps.

Results and Discussion

A comparative analysis of the literature showed that PCOS increases the risk of hyperplasia and polyps by 2–3 times. NAFLD disrupts estrogen metabolism, enhancing hyperestrogenism. Hypothyroidism causes hormonal and metabolic shifts that contribute to the formation of polyps. When PCOS, NAFLD, and hypothyroidism are combined, the risk of developing and recurring polyps increases several times.

The disadvantage of existing studies is the fragmentation of data and the lack of integrated models. Mathematical modeling makes it possible to quantitatively assess the contribution of each factor. Systems of differential equations describe the dynamics of the hormonal background, while agent-based models reflect the endometrial microenvironment. Promising directions include the use of multifactorial models with machine learning methods.

CONCLUSION

1. Endometrial polyps have a multifactorial nature; key factors are endocrine, hepatobiliary, and thyroid disorders.
2. PCOS, NAFLD, and hypothyroidism, through the mechanism of hyperestrogenism, significantly increase the risk of polypogenesis.
3. Mathematical modeling opens new possibilities for integrating clinical data and predicting risk.
4. The creation of multilevel models will make it possible to move toward personalized approaches in diagnosis and treatment.

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