



COMPREHENSIVE ASSESSMENT OF RISK FACTORS AND MATHEMATICAL MODELING IN PREDICTING ADENOMYOSIS DURING THE PERIMENOPAUSAL PERIOD

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ABSTRACT

In this study, clinical, instrumental, and immunological risk factors were comprehensively evaluated in order to predict the development and severity of adenomyosis in women during the perimenopausal period, and a mathematical model was developed. As a result, the main risk factors were identified, and it was substantiated that their combination allows for reliable assessment of the probability of disease development and serves as an effective tool for individualized prediction.

Relevance. In recent years, adenomyosis has been recognized as one of the most common gynecological diseases that negatively affects women's reproductive health. Particularly during the perimenopausal period, the incidence of this pathology increases, and the hormonal changes and metabolic disturbances characteristic of this stage play an important role in its development [4, 6]. Adenomyosis is characterized by the invasion of endometrial tissue into the uterine myometrium and is associated with pain syndrome, abnormal uterine bleeding, and a decreased quality of life [3, 5].

During the perimenopausal period, the imbalance between estrogen and progesterone enhances endometrial proliferation and leads to the activation of pathological foci. At the same time, changes in the immune system, increased activity of inflammatory mediators and cytokines further complicate the pathogenesis of the disease [9, 11]. Modern studies emphasize that immunological and molecular mechanisms play a leading role in the development of adenomyosis [12, 14].

In addition, increasing attention is being paid to the role of risk factors in the development of adenomyosis. Metabolic disorders, endocrine pathologies, gynecological interventions, and features of reproductive history are considered the main factors that increase the risk of disease development [1, 2]. However, the possibilities of predicting the disease through a comprehensive assessment of these factors and determining their interactions have not been sufficiently studied.

In modern medicine, mathematical modeling methods are widely used for disease prediction. This approach makes it possible to integrate various clinical, instrumental, and laboratory indicators to determine the probability of disease development [7, 8]. Especially in

multifactorial diseases such as adenomyosis, the use of mathematical models is of great importance for individualized prediction and the development of a differentiated approach.

In this regard, a comprehensive assessment of risk factors for adenomyosis in perimenopausal women, as well as the development of prediction methods based on mathematical modeling, represents a relevant scientific and practical problem.

Materials and Methods. This study was conducted during 2023–2025 at the multidisciplinary clinic of Samarkand State Medical University. A total of 120 women in the perimenopausal period (45–52 years) diagnosed with adenomyosis were included in the study. Additionally, medical records of 45 perimenopausal women were analyzed retrospectively.

The study design included both prospective and retrospective observational methods. During the study, clinical, instrumental, and laboratory parameters of the patients were comprehensively evaluated. Clinical assessment included anamnesis data, patient complaints, the presence of somatic and gynecological diseases, reproductive history, and previously performed surgical interventions.

Within the scope of instrumental examinations, ultrasound of the pelvic organs was performed, including comprehensive ultrasonography and compression elastography. As an endoscopic examination, hysteroscopy was used to assess the uterine cavity and the condition of the endometrium. Laboratory investigations included the determination of immunological and biochemical parameters. In particular, the level of interleukin-6 in blood serum was measured using enzyme-linked immunosorbent assay (ELISA), and anti-embryonic autoantibodies were assessed using the ELIP test. Based on the obtained data, mathematical modeling methods were applied to identify risk factors for the development of adenomyosis and to assess their significance. In developing the prognostic model, multivariate analysis methods were used, including correlation and regression analysis, to evaluate the influence of each factor on disease development.

Statistical analysis was performed using modern software tools. The results were expressed as mean values with their confidence intervals, and statistical significance was considered at $p < 0.05$. The diagnostic value of the models was assessed in terms of sensitivity, specificity, and predictive accuracy.

Results. The results of the conducted study demonstrated that the development of adenomyosis and its severe course in perimenopausal women have a multifactorial nature. Based on the analysis of clinical and anamnestic data, the main risk factors were identified as metabolic disorders, particularly obesity and diabetes mellitus, thyroid diseases, early menarche, multiple gynecological interventions, and ovarian cysts.

The results of the retrospective analysis showed that in 33% of patients with mild adenomyosis, progression to stage II of the disease was observed within one year, confirming the progressive nature of the condition. A direct relationship was identified between clinical manifestations and risk factors, with severe forms of the disease occurring more frequently in patients with metabolic and endocrine disorders. According to instrumental examination results, changes in the myometrium detected by ultrasound and elastography corresponded to the severity of the disease. The use of compression elastography demonstrated a sensitivity of 87% and specificity of 98% in diagnosing adenomyosis, indicating its high diagnostic value.

Analysis of immunological parameters revealed that elevated levels of interleukin-6 showed a positive correlation with disease severity ($r = 0.65$), confirming its pathogenetic and prognostic significance. Additionally, a moderate positive correlation was found between the level of immunoreactivity and disease severity ($r = 0.55$).

Based on the obtained data, a mathematical prognostic model was developed. In this model, clinical, instrumental, and immunological indicators were integrated, allowing assessment of the risk of disease development. The modeling results demonstrated that the combination of key risk factors provides high accuracy in predicting severe forms of adenomyosis. Thus, the mathematical model developed on the basis of a comprehensive approach proved to be an effective tool for assessing the risk of adenomyosis development and for individualized prediction in perimenopausal women.

Conclusion. The results of the study confirmed that the development and severity of adenomyosis in perimenopausal women is a multifactorial process. Key risk factors were identified based on clinical, instrumental, and immunological indicators, and their interrelationship was shown to be important in disease prognosis.

The developed mathematical model, through comprehensive evaluation of these factors, enables early prediction of the risk and severe forms of adenomyosis. This approach provides individualized prediction and can be recommended as an effective tool for differential patient management and the selection of optimal treatment strategies.

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