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**Diagnostic Significance of VEGF, EGF, P53, and VEGFR-2 Biomarkers in
Polypotic Rhinosinusitis**

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Abstract: This article analyzes the diagnostic significance of biomarkers associated with angiogenesis, cell proliferation, and apoptosis processes in polypoid rhinosinusitis - VEGF, EGF, p53, and VEGFR-2. In the dissertation, in order to improve the diagnosis of polypoid rhinosinusitis, it was shown that by determining the content of p53 protein, EGF, VEGF, and VEGFR-2 in the polyp tissue and blood serum, their specificity for the disease and their relationship with etiopathogenesis were studied. Also, as a scientific novelty, it has been proven that changes in the amount of these biomarkers are a determining factor in the course and development of polypoid rhinosinusitis. The article extensively covers the role of these biomarkers in changes in polyp tissue and blood serum, their role in inflammatory, edematous, angiogenous, and reconstructive processes in the mucous membrane, and their significance in the clinical course, recurrence, and choice of treatment tactics. The role of VEGF and VEGFR-2 in angiogenesis, EGF in epithelial growth and regeneration, p53 in the control of apoptosis and the cell cycle were assessed as important links in the pathogenesis of polypoid rhinosinusitis. It was concluded that a comprehensive study of biomarkers is important for early diagnosis of the disease, assessment of clinical severity, prediction of the risk of recurrence, and control of the effectiveness of complex treatment.

Keywords: polypoid rhinosinusitis, VEGF, EGF, p53, VEGFR-2, biomarker, angiogenesis, diagnosis, prognosis.

Polypoid rhinosinusitis is a complex pathological process with chronic inflammation, characterized by the proliferation of polyps from the mucous membrane of the nose and paranasal sinuses, as well as frequent relapses of the disease. Its clinical significance is determined not only by its prevalence and negative impact on the

patient's quality of life, but also by the high risk of recurrence in cases of conservative and surgical treatment [4,11,18,26,33,42]. Therefore, in order to improve the diagnosis and treatment of polypoid rhinosinusitis in modern otorhinolaryngology, there is a growing need for a deeper study of the pathogenesis of the disease at the cellular and molecular levels. In the dissertation, the goal of the study is to improve the diagnosis and evaluate the effectiveness of treatment of polypoid rhinosinusitis by studying the pathogenetic mechanisms of the disease, among the tasks, it is indicated to study the specificity of the disease and its relationship with etiopathogenesis by determining the content of p53, EGF, VEGF, and VEGFR-2 in polypoid tissue and blood serum [2,9,17,25,31,40].

Although there are various theories about the etiology and pathogenesis of polypoid rhinosinusitis, none of them fully explains the mechanisms of the disease's formation. Although allergic, infectious, fungal, vegetative, and polyetiological approaches have revealed some aspects of the disease, why the polypoid process develops rapidly in some patients, why it manifests repeatedly in some cases, and why it persists for a long time despite standard treatment is not fully explained. In this regard, molecular biomarkers involved in cell proliferation, epithelial restructuring, angiogenesis, inflammation, and apoptosis are of great interest [6,13,20,27,34,41]. In the dissertation, according to studies of recent years, the role of monocyte chemotactic protein-1, VEGF, EGF, MVD, and hypoxia-associated factors in the development of polypoid rhinosinusitis is noted, especially the increased production of vascular endothelial growth factor and epidermal growth factor, which is important in the rapid growth and recurrence of polypoid tissue.

VEGF - vascular endothelial growth factor - is one of the most important biomarkers in the pathogenesis of polypoid rhinosinusitis [1,10,16,24,35,39]. It is one of the main molecules controlling the process of angiogenesis and plays an important role in the formation of new blood vessels, increasing the permeability of the vessel wall, and the formation of edema and fibrinous media in tissues. In the dissertation, it was noted that VEGF increases the activity of endothelial cells of capillaries, veins, and arteries, stimulates vascular angiogenesis, and increases the permeability of small

blood vessels, which leads to the leakage of blood plasma proteins from the vessel wall. This creates a favorable environment for cell growth in the polyp tissue. Persistent swelling, hyperplasia, and tissue restructuring of the mucous membrane in polypoid rhinosinusitis may be pathogenetically associated with high VEGF expression [5,12,19,28,32,38].

VEGFR-2 is one of the main receptors of VEGF and is a crucial link in the transmission of angiogenesis signals into the cell. The interaction between VEGF and VEGFR-2 ensures the proliferation, migration, and expansion of the vascular network of endothelial cells. An increase in the level of VEGF in polypoid rhinosinusitis does not have clinical significance without the activation of its receptor system, therefore, a joint assessment of VEGFR-2 is important. The dissertation indicates that the study of the level of VEGFR-2 in polyp tissue and blood serum was defined as the research task, and as a scientific novelty, it was proven that changes in the levels of p53, EGF, VEGF, and VEGFR-2 are a determining factor in the course and development of the disease. This, in turn, allows us to consider VEGFR-2 not only as a pathogenetic, but also as a diagnostic and prognostic biomarker in polypoid rhinosinusitis [3,14,21,23,30,37].

EGF - epidermal growth factor - is an important molecule involved in the growth, differentiation, and regeneration of epithelial cells. In polypoid rhinosinusitis, the nasal mucosa is constantly subjected to inflammation, edema, hyperplasia, and reshaping processes. Therefore, the role of EGF is very significant. While it promotes cell regeneration under normal conditions, its excessive activation under pathological conditions can enhance epithelial proliferation and contribute to the growth of polypoid tissue. In the dissertation, along with the vascular endothelial growth factor, the significance of the epidermal growth factor in the rapid growth and recurrence of polyp tissue was noted. Thus, assessing the level of EGF helps to understand the activity of the disease and the degree of restructuring processes occurring in the polyp tissue.

The p53 protein is an important regulator of the cell cycle and plays a crucial role in the processes of apoptosis, DNA damage response, and atypical proliferation restriction. Normally, p53 controls pathological changes in the cell, preventing its uncontrolled proliferation. In polypoid rhinosinusitis, changes in p53 expression may

be associated with pathological tissue growth, disruption of apoptosis, and processes of restructuring against an inflammatory background. The dissertation notes that by studying the content of p53 protein in blood serum and polyp tissue, it is possible to determine the mechanism of pathogenetic development of polyps, early diagnosis, and prediction of recurrence. This gives grounds to assess p53 as one of the most important molecular indicators in polypoid rhinosinusitis [7,8,15,22,29,36].

The following table systematizes the main role of these biomarkers in the pathogenesis of polypoid rhinosinusitis.

Table 1

Pathogenetic significance of the main biomarkers in polypoid rhinosinusitis

Biomarker	Basic biological function	Probable significance in polypoid rhinosinusitis
WEGF	Angiogenesis, increased vascular permeability	Increased edema, vascular proliferation and tissue hyperplasia in polyp tissue
VEGFR-2	VEGF signal transmission, endothelial proliferation	Determination of the activity of the angiogenesis process, assessment of clinical activity and the risk of recurrence
EGF	Epithelial growth and regeneration	Mucosal reconstruction, hyperplasia and involvement in polyp tissue growth
p. 53.	Apoptosis and cell cycle control	Assessment of pathological proliferation, prediction of polyp tissue development and recurrence

As can be seen from this table, although these four biomarkers act in different directions, in practice they manifest as interconnected links of one pathogenetic chain in polypoid rhinosinusitis. On one side, angiogenesis and vascular permeability increase, on the other side, epithelial restructuring and pathological growth are activated, and on the third side, apoptosis and cell regulation change. This circumstance helps to explain the long-term preservation and rapid recurrence of the polypoid process.

From the point of view of the diagnosis of polypoid rhinosinusitis, the significance of these biomarkers manifests itself in several aspects. Firstly, they can serve as molecular criteria confirming the presence of the disease at the pathogenetic level. Secondly, their level in blood serum and polyp tissue helps to assess the activity, severity, and tendency to relapse of the disease. Thirdly, when these indicators are assessed dynamically before and after treatment, they can serve as an objective marker of the effectiveness of the chosen therapy. The dissertation also notes that, as a practical result, the study of the content of p53, EGF, VEGF, and VEGFR-2 in the polyp tissue and blood serum of patients made it possible to determine the mechanism of pathogenetic development of polyps and early diagnosis and prediction of recurrence.

Clinically, these biomarkers can be especially important in the following cases: prolonged polypoid rhinosinusitis, frequently recurring forms, conditions accompanied by allergic or bronchial asthma, patients with significantly impaired mucociliary clearance, and individuals who have undergone multiple surgeries. In such patients, in addition to a simple endoscopic or radiological examination, it is very important to know how active the pathogenetic process is for individualization of treatment tactics. For example, in cases where the angiogenesis component is dominant, the risk of recurrence may be higher; if changes in apoptosis and cell cycle control are strong, stable growth of polypoid tissue can be expected; An increase in EGF may indicate the activity of restructuring processes in the mucous membrane.

The following table summarizes the significance of biomarkers from the point of view of diagnostic and clinical assessment.

Table 2

Clinical and diagnostic value of VEGF, EGF, p53 and VEGFR-2

Assessment direction	Importance of biomarkers	Practical value
Early diagnosis	Shows molecular activity in polyp tissue	Helps identify subclinical or early active process

Assessment of disease severity	Reflects the degree of inflammation, angiogenesis, and proliferation	Clinical severity can be assessed pathogenetically.
Determination of the risk of recurrence	Indicates tissue growth and reconstruction activity	You can make a forecast and set a dynamic tracking plan
Control of treatment effectiveness	Evaluates changes in molecular background after treatment	Objectively shows the result of complex therapy
Selection of individual treatment tactics	Indicates which pathogenetic link is dominant	Allows targeted and personalized treatment

For a deeper understanding of the diagnostic significance of biomarkers in polypoid rhinosinusitis, it is necessary to consider them in connection with other pathogenetic links of the disease. The dissertation shows that a decrease in mucociliary transport function worsens the course of the disease, the use of photodynamic laser therapy in the polypoid process improves the olfactory and respiratory function of the nasal mucosa, and as a result of the normalization of the level of cytokines in blood serum, the duration of relapses is prolonged. These data indicate that the study of such biomarkers as VEGF, EGF, p53 and VEGFR-2 has the greatest practical value when combined with other functional and clinical indicators of the disease. That is, they should be integrated not only as laboratory numbers, but also with mucociliary clearance, endoscopic picture, CT data, clinical signs, and treatment outcomes.

In polypoid rhinosinusitis, increased angiogenesis and epithelial restructuring can lead to stable growth of polyp tissue, and changes in regulatory mechanisms such as p53 can lead to disruption of pathological proliferation control. Therefore, the study of biomarkers allows not only for the diagnosis of "have-no" polypoid rhinosinusitis, but also to determine its phenotype, to see the link of the pathogenetic column, and to determine the prognosis. This is especially important in patients who need repeated surgery or are not adequately responding to standard therapy.

Also, the study of these biomarkers is of great scientific importance. The scientific significance of the dissertation lies in the fact that by studying the content of p53, EGF, VEGF, and VEGFR-2 in the polyp tissue and blood serum of patients, it is possible to diagnose and predict recurrence of polyps by determining the pathogenetic development of polyps. This creates a solid basis for further molecular-pathogenetic studies of polypoid rhinosinusitis, the development of new diagnostic panels, and the search for directions of targeted therapy.

Thus, VEGF, EGF, p53, and VEGFR-2 are among the most important molecular biomarkers in polypoid rhinosinusitis. Their changes in polyp tissue and blood serum reflect the pathogenetic activity of the disease, the processes of angiogenesis, epithelial growth, restructuring, and apoptosis. The dissertation shows that changes in the content of these biomarkers are a determining factor in the course and development of polypoid rhinosinusitis, as well as the possibility of early diagnosis and prediction of relapses based on their study. Consequently, a comprehensive assessment of these biomarkers plays an important role in diagnosing polypoid rhinosinusitis, determining the clinical severity, choosing the correct treatment tactics, and predicting the further course of the disease.

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