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PERSPECTIVES OF THE METHODS' DEVELOPMENTS FOR THE FUNCTIONAL DIAGNOSIS OF NASAL BREATHING

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Abstract. *Perspectives of development of methods for functional diagnostics of nose respiration are described. For the development of modern rhinomanometry, primary tasks are not only metrological provision with means of measuring airflow indicators, but also methodological, minimizing processing errors, errors arising from one-time measurements and incorrect averaging of data. An important role here should be played by information technologies, which reduce uncertainty in measurements, by taking into account the properties of the test object, methods of automated processing, analysis and interpretation of diagnostic data. Therefore, campaigns and technical solutions aimed at improving the methods of functional diagnostics in rhinology by studying the effect of intranasal structures on the characteristics of nasal airflow and justifying additional diagnostic indicators are currently relevant. It is also advisable to modernize diagnostic equipment based on an analysis of the methodological features of nasal breathing testing and independent verification of aerodynamic parameters with forced nasal breathing to develop evidence-based testing methods based on quantitative criteria and instrumentally measured objective diagnostic data.*

Keywords*: rhinomanometry, nasal breathing, flow rate, differential pressure.*

Introduction. Currently, medical diagnostics is based on an evidence-based approach based on the use of precision instrumentation and methodologically correct information technologies for obtaining reliable quantitative data on pathological processes in the human body. At the present stage, the most active evolution is observed in functional diagnostic methods, which are aimed at registering quantitative indicators of the physiological functions of an organ (or the whole organism) and allow for timely detection of disorders depending on specific pathological changes [1-3]. Such diagnostic data and allow you to link the anatomical, morphological and physiological parameters of the studied organ to clarify the picture of the pathological process and, therefore, are particularly useful for the clinician. The use of functional studies is also relevant in professional selection, routine examinations and for sports medicine in order to determine the physical abilities of the subjects.

Rhinology (the science of the study of nasal breathing) is currently one of the least supported by evidence-based methods of functional diagnostics. Despite the possibilities of modern rhinomanometric equipment and the corresponding specialized processing software, there is still no clear correlation between the patient's subjective sensations and the indicators of the air flow through the nasal cavity [4]. Improving the accuracy of measurements and adjusting the values of the conditional physiological norm, depending on age, gender and other features, does not allow to solve this problem [1-5]. Studies in the field of aerodynamics of the upper respiratory tract are devoted to the work of well-known domestic and foreign experts, and the International Committee on Standardization of Rhinomanometry [6] was established and is functioning. The complexity of the problem, various approaches and methodological aspects of research make it difficult to interpret the diagnostic data obtained, which prevents the widespread introduction of methods and hardware for the functional diagnosis of nasal breathing disorders in clinical practice. Therefore, it is advisable to analyze current trends in the development of methods and means for testing nasal breathing and to identify promising approaches.

Research results. The nasal cavity is an air channel with a complex variable cross section and communicating from the front through the nasal openings — the nostrils with the environment and

from behind, through the choanal region, with the nasopharynx. The walls of the nasal cavity are formed by bone and cartilage structures. In this case, the nasal cavity is divided by the nasal septum into two conditionally symmetrical parts, called the nasal left and right nasal passages [1-3].

One of the diagnostically important indicators of the functioning of the respiratory system as a whole is the coefficient of the integral aerodynamic resistance of the respiratory tract. At the same time, there is a clear correlation between the presence of bronchial obstruction and impaired air conduction of the upper respiratory tract. At the same time, excessive reduction of nasal resistance is physiologically ineffective due to the increased energy costs of alveolar ventilation. So mouth breathing (with significantly less resistance) causes dyspnea and rapid fatigue. In this case, the muscles of the pharynx, palate and tongue contribute to an increase in air resistance. So the resistance of the glottis, which is normally about 7% of the total resistance of the respiratory tract, can increase by 4 to 5 times with oral breathing. In modern rhinology, aerodynamic nasal resistance with quiet breathing is normally in the range of values of 0.4 ÷ 0.6 of the total resistance of the respiratory tract [7].

The simplest ways to determine the degree of patency of the nasal passages are the Voyachek samples – a study of the degree of air flow deviation of the plumes brought to the patient's nostrils, Boiler tests, which allow determining the functioning of the anterior section of the nasal valve by the degree of improvement in nasal breathing, as well as Kohl's test, in which nasal breathing is investigated when the wing of the nose is outward by introducing wooden chips or button into the vestibule of the nose. to probe [7]. The same simple methods for assessing breathing through each half of the nose are methods based on analyzing the degree of fogging (condensate spot size) of the mirror surface brought to the nostrils during expiration, for example, the Glyattsel test [7]. The above methods are of high quality, have low accuracy and do not meet modern standards of evidence-based medicine.

At present, the main quantitative method for assessing the function of nasal breathing is rhinomanometry, which analyzes the measured parameters passing through the nose of air flow and causing it, pressure drop [1–4, 7, 8]. Over the past three decades, many methods and tools have been proposed for carrying out rhinomanometry with the registration of various characteristics of nasal airflow. The computer rhinomanometry method used in recent years [1–4, 7–10] makes it possible to obtain various quantitative indicators characterizing disorders of nasal breathing. The coefficient of aerodynamic nasal resistance is expressed as the ratio of the pressure drop across the nasal cavity to the value of the volume flow rate of air. Modern rhinomanometers are sophisticated electronic devices based on the use of miniature precision measuring transducers of pressure and airflow velocity and allow to obtain graphical dependencies of the airflow parameters in the nasal cavity using specialized software. At the same time, methods of rhinomanometry are divided into two groups according to the location of pressure measurement points - anterior and posterior [10].

Anterior active rhinomanometry is that a tube with a pressure sensor and a sealed obturator is inserted into one half of the nose through its vestibule, and therefore this half of the nasal cavity is excluded from the breathing process. Due to such obturation of one half of the nose, the pressure drop according to Pascal's law is measured at the exit from the other half of the nose, air flow is measured simultaneously and air resistance indicators are calculated in [kPa / (l / s)]. The main disadvantages of this method include the inaccuracy of measurements of total nasal resistance due to alternate obturation of one of the nasal passages, which leads to possible changes in the muscular system of the nose in the intervals between right- and left-sided studies and reflex changes in the cross-section of the nasal cavity. At the same time, it is often proposed to introduce correction factors for calculating the conductivity of parallel pipelines to calculate the integral aerodynamic resistance of parallel nasal passages, which, in general, reduces the reliability of diagnostics.

Rear active rhinomanometry [1-4] provides for the placement of a pressure transducer in the nasopharynx with a tube in the mouth with tightly clamped lips. In this case, the distal end of the tube should not cause a gag reflex. For the implementation of this method, the patient requires some getting used to the implementation of respiratory maneuvers and a kind of simplest training before the study.

It should be noted that regardless of the location of the measuring transducers and the processing of measurement results, the method of rhinomanometry provides for the analysis of data of two indicators - pressure drop and air flow in the nasal passages. Methods based on the analysis of only one of the parameters, for example, air flow, are called rhinoflowmetry, pneumotachometry, nasal spirometry and do not allow to evaluate nasal resistance [4, 5, 7]. It should be borne in mind that the volume flow rate of air during nasal breathing is an extremely variable parameter and cannot replace the complex indicators of rhinomanometry [7].

Also known devices that allow to determine the dynamic pressure in the nasal passages by introducing a capillary tube in the corresponding parts of the nasal cavity [7]. However, the complexity of the measurement procedures associated with controlling the position of the distal end of the tube leads to the appearance of instrumental errors and prevents the widespread introduction of these methods in clinical practice.

The most well-known commercially available modern rhinomanometers are ATMOS 300 (ATMOS Medical system GMB, Germany) [4] and their analogues based on the method of anterior active rhinomanometry, which, according to developers, is the least uncomfortable for the patient.

Recently, a method has emerged called rhinosistometry, in which aerodynamic nasal drag is calculated not by patented algorithms and model representations, but directly at each point of the respiratory cycle [7].

Also interesting is the development of the method of acoustic rhinometry, which is based on scanning the nasal cavity with a sound frequency (from 150 to 10,000 Hz) to determine some morphometric parameters relating to the cross-sectional area of the nasal cavity and the volumes of the upper respiratory tract sections under study [11]. Acoustic rhinometry allows you to perform a static measurement of the anatomical dimensions of the nasal cavity and determine the degree of mechanical obstruction of the upper respiratory tract. According to the authors of [12], the minimum area of the nasal passage is normally observed on average at a distance of about 2 ... 2.35 cm from the entrance and varies from 0.62 to 0.67 cm2, respectively. We study the correlation between the subjective assessment of the degree of difficulty in breathing by the patient, the data of posterior and anterior active rinomanometry, and acoustic rhinometry. The methodological and clinical aspects of the use of acoustic rhinometry [11, 12] and the comparison of its performance with the data of anatomical computed tomographic mapping [13], as well as the results of endoscopy of the nasal cavity [14] are considered. It is shown that, according to acoustic rhinometry data, a resonance is observed in the area behind the nasal valve, which does not correspond to the picture of real anatomical structures, endoscopy allows for more accurate visualization of anatomical landmarks, computed tomography data correlates with acoustic rhinometry results, but the latter is relevant mainly for research anterior nasal cavity [11–13]. However, acoustic rhinometry is used, for example, to study the nasal cycle - obtaining data on the cross-sectional area of the nasal passages in dynamics and the objectification of treatment results. A promising direction is the objectification of diagnostic results in the study of respiratory phenomena, for example, through the methods of spectral analysis of auscultation data arising from breathing noise.

The results of functional studies of the upper respiratory tract have a high variability, therefore, despite the rather large number of instruments and methods, so far no clear criteria for rhinomanometric diagnostics that meet the standards of evidence-based medicine, such as spirometric indicators, have been developed. At the same time, if the methods and means of spirometry are currently routine in medical practice and possess precise differential diagnostic criteria, then rhinomanometry needs to develop quantitative indicators for monitoring functional disorders of the upper respiratory tract.

Conclusions. The complexity of the methods of functional diagnostics lies in the fact that the presence of high-precision measuring means of physical quantities does not yet ensure the quality of diagnostics in the absence of a standard [4]. For the development of modern rhinomanometry, primary tasks are not only metrological provision with means of measuring airflow indicators, but also methodological, minimizing processing errors, errors arising from one-time measurements and incorrect averaging of data. An important role here should be played by information technologies, which reduce uncertainty in measurements, by taking into account the properties of the test object, methods of automated processing, analysis and interpretation of diagnostic data. At the same time, the absence of an unambiguous connection of functional rhinomanometric respiration indicators with quantitative anatomical and morphometric parameters obtained using computed tomography does not allow for functional diagnostics of nasal breathing solely by intrascopic data, which, unfortunately, is often observed in practical rhinology due to the lack of clinics specialized functional diagnostic tools.

Therefore, campaigns and technical solutions aimed at improving the methods of functional diagnostics in rhinology by studying the effect of intranasal structures on the characteristics of nasal airflow and justifying additional diagnostic indicators are currently relevant. It is also advisable to modernize diagnostic equipment based on an analysis of the methodological features of nasal breathing testing and independent verification of aerodynamic parameters with forced nasal breathing to develop evidence-based testing methods based on quantitative criteria and instrumentally measured objective diagnostic data.

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