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INNOVATIVE PEDAGOGICAL TECHNOLOGIES IN TEACHING THE MORPHOLOGY OF BRONCHI IN CHRONIC DISEASES OF THE LOWER RESPIRATORY TRACT

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Abstract. The article examines the application of innovative pedagogical technologies in teaching the morphology of bronchi in chronic diseases of the lower respiratory tract to medical students. Mastering the pathomorphology of the bronchial wall is challenging due to the abstract nature of microscopic changes and the need to integrate structural data with the clinical picture. A teaching model is proposed that combines digital (virtual) microscopy, three-dimensional visualization, interactive morphological atlases, clinical-morphological case-based learning and problem-based learning. Didactic techniques for visualizing the key morphological features of chronic bronchitis, bronchial asthma, chronic obstructive pulmonary disease and bronchiectasis are described. It is shown that integrating innovative technologies with traditional methods promotes deeper and more conscious mastery of the material, develops clinical-morphological thinking and increases learning motivation. The expediency of the systematic introduction of innovative pedagogical technologies into the teaching of special pathological morphology is substantiated.

Keywords: bronchial morphology, pathomorphology, chronic diseases of the lower respiratory tract, medical education, innovative pedagogical technologies, virtual microscopy, clinical-morphological approach, visualization.

Introduction

The training of highly qualified physicians is impossible without a thorough understanding of morphological disciplines, which provide a fundamental understanding of the structure of organs and tissues in health and disease. Bronchial morphology and its changes in chronic lower respiratory tract diseases occupy a special place in medical education, as structural changes in the bronchial wall underlie the clinical manifestations and outcomes of such socially significant diseases as chronic bronchitis, bronchial asthma, chronic obstructive pulmonary disease (COPD), and bronchiectasis.

Chronic lower respiratory diseases are among the leading causes of morbidity and mortality worldwide, making high-quality training of future physicians in this field highly relevant. Understanding the morphological basis of these diseases—bronchial wall remodeling, changes in the epithelium, basement membrane, smooth muscle layer, and submucosal glands—is essential for developing clinical judgment. However, teaching specific pathological morphology is fraught with a number of objective difficulties. Microscopic changes are abstract and difficult to memorize with traditional descriptive presentation, while the gap between structural data and the clinical picture hinders the development of a holistic understanding of the disease. Traditional teaching methods, based primarily on working with static slides and illustrations, do not always provide the necessary level of clarity, interactivity, and student engagement.

Under these conditions, the role of innovative pedagogical technologies that allow for the visualization of morphological processes, the integration of structural and clinical data, and the enhancement of student cognitive activity is increasing. The use of such technologies in teaching bronchial morphology in chronic lower respiratory tract pathology remains understudied and requires systematic methodological consideration. The purpose of the study

To substantiate and describe a model for the application of innovative pedagogical technologies in teaching bronchial morphology in chronic lower respiratory diseases, ensuring increased clarity, awareness of learning, and the development of students' clinical and morphological thinking.

Materials and Methods

This study is theoretical and methodological in nature. The object of the study was the process of teaching a section of specific pathological morphology devoted to bronchial changes in chronic lower respiratory diseases. The subject of the research is innovative pedagogical technologies applicable to the study of this section.

The following methods were used: theoretical analysis of scientific, methodological, and medical literature on the teaching of morphological disciplines; systematization and classification of pedagogical technologies according to their didactic potential; educational process modeling; and a summary of pedagogical experience in teaching pathological morphology.

Based on the analysis, pedagogical technologies with the greatest potential for studying bronchial morphology were identified: digital (virtual) microscopy, 3D visualization and modeling, interactive digital morphological atlases, clinical and morphological case analysis (case-based learning), problem-based learning, as well as information visualization methods and gamification elements. For each technology, didactic functions and methods of their implementation in relation to specific morphological objects are defined.

Results and discussion

Morphological characteristics of the bronchi in chronic pathology as a teaching subject.

Normally, the bronchial wall consists of a mucous membrane (multi-stratified ciliated epithelium with goblet cells, basement membrane, and lamina propria), a smooth muscle layer, a submucosa with serous-mucous glands, cartilaginous plates, and adventitia. In chronic lower respiratory diseases, these structures undergo consistent changes, which form the basis of this section.

In chronic bronchitis, key morphological features include goblet cell hyperplasia, hyperplasia and hypertrophy of submucous glands (increased Reid index), chronic inflammation, and mucus hypersecretion. In bronchial asthma, thickening of the basement membrane (subepithelial fibrosis), smooth muscle hypertrophy and hyperplasia, goblet cell hyperplasia, eosinophilic inflammation, and epithelial damage are characteristic. In COPD, small airway remodeling, goblet cell and squamous cell metaplasia of the epithelium, and peribronchial fibrosis predominate. In bronchiectasis, bronchial wall destruction, persistent dilation, chronic inflammation, and fibrosis are observed.

These changes are abstract, numerous, and difficult to remember, necessitating the use of technologies that enhance clarity and connect structure with function and clinical manifestations.

Innovative pedagogical technologies and their didactic functions.

Based on the analysis, a teaching model is proposed in which innovative technologies perform specific didactic functions (Table 1).

Table 1. Innovative pedagogical technologies in teaching bronchial morphology

Technology	Didactic function	Application example
Virtual (digital) microscopy	Detailed examination of a microscopic specimen with zooming	Analysis of digitalized bronchial sections in asthma and COPD
3D visualization and modeling	Spatial representation of the structure of the bronchial wall	3D model of bronchial wall remodeling
Interactive morphological atlas	Independent navigation by features	Comparison of normal and abnormal conditions in a digital atlas
Clinical and morphological analysis (CBL)	Integration of structure and clinical presentation	Analysis of a COPD case with morphology and symptom analysis
Problem-based learning (PBL)	Development of analytical thinking	Search for causes of obstruction based on morphological data
Visualization and gamification	Systematization and assessment of knowledge	Clusters, comparison tables, and surveys in Kahoot

Virtual microscopy enables the transition from a limited number of glass slides to high-resolution digital images accessible to every student. The ability to zoom, annotate, and share images makes the study of subtle features (basement membrane thickening, glandular hyperplasia) more accessible and visual.

Three-dimensional visualization and modeling overcome the main limitation of traditional histology—the two-dimensionality of sections. Three-dimensional models of the bronchial wall clearly demonstrate the spatial relationships of layers and the nature of their remodeling, which is especially important for understanding the mechanisms of bronchial obstruction.

Interactive morphological atlases allow students to work independently at their own pace, comparing normal and pathological conditions, which aligns with the principles of personalized learning and develops independent analytical skills.

Clinical and morphological case analysis (case-based learning) ensures the integration of morphological data with the clinical picture. Analyzing a specific case, the student connects structural changes in the bronchus with symptoms, examination data, and the outcome of the disease, which develops holistic clinical and morphological thinking—a key professional competency for physicians.

Problem-based learning activates cognitive activity: students are asked to independently explain the mechanism of obstruction or hypersecretion based on the morphological picture, and formulate and test hypotheses. This approach shifts the student from a passive listener to a researcher.

Information visualization methods (clusters, comparative tables, diagrams) and gamification elements (interactive surveys, educational games) facilitate the systematization of extensive morphological material and increase learning motivation.

Integration of technologies and expected educational effects.

The greatest effectiveness is achieved not by using these technologies in isolation, but by systematically and integratedly combining them with traditional methods. The following lesson logic is advisable: updating basic knowledge of normal bronchial morphology; studying pathomorphological changes using virtual microscopy and 3D models; clinical and morphological case analysis; problem-solving; systematization of material using visualization tools and learning assessment.

This model ensures the implementation of the principles of clarity, activity, integration, and individualization of learning. The expected educational benefits include increased awareness and retention of morphological material, development of clinical and morphological thinking, increased motivation and engagement, and the development of skills for independent work with morphological information.

It should be emphasized that innovative technologies do not replace classical microscopy and preparation, but rather complement and enhance them, making the learning process more visual, interactive, and clinically oriented.

Conclusion

Teaching bronchial morphology in chronic lower respiratory diseases presents significant methodological challenges due to the abstract nature of morphological changes and the need to integrate them with the clinical picture. The use of innovative pedagogical technologies allows us to successfully overcome these challenges.

The proposed model, based on a combination of virtual microscopy, 3D visualization, interactive atlases, clinical and morphological case analysis, and problem-based learning, enhances clarity, improves student understanding, and develops students' clinical and morphological thinking. The systematic implementation of innovative pedagogical technologies in the teaching of specific pathological morphology is a promising area for improving medical education.

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