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Modern approaches to the diagnosis and prevention of pneumoconiosis in occupational settings

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ABSTRACT

Pneumoconiosis remains a significant occupational health concern associated with long-term exposure to industrial aerosols and toxic substances. It has been established that the development of pathological changes in lung tissue is determined by multiple factors, including the duration and intensity of exposure, physicochemical properties and concentration of inhaled particles, as well as individual susceptibility. Historically, pneumoconiosis was predominantly attributed to inhalation of dust containing free crystalline silica. However, contemporary evidence indicates that the disease may also arise as a result of the combined or synergistic effects of industrial aerosols with complex composition. These aerosols may include fibrogenic, toxic, allergenic, and irritant components, contributing to diverse clinical manifestations and disease heterogeneity. This evolving understanding highlights the need for advanced diagnostic approaches and comprehensive preventive strategies in occupational settings.

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Меҳнат гигиенасида пневмокониозни ташхис қилиш ва профилактикасининг замонавий ёндашувлари

Калит сўзлар:
касб касалликлар, пневмокониозлар, саноат аэрозоллари, ташхис қилиш (диагностика) усуллари,

АННОТАЦИЯ

Пневмокониоз саноат аэрозоллари ва заҳарли моддаларнинг узоқ муддатли таъсири билан боғлиқ жиддий касбий саломатлик муаммоси бўлиб қолмоқда. Ўпка тўқималарида патологик ўзгаришларнинг ривожланиши кўплаб омиллар, жумладан таъсир қилиш

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олдини олиш чоралари.

давомийлиги ва интенсивлиги, физик-кимёвий хусусиятлар ва нафас олаётган заррачаларнинг концентрацияси ва индивидуал сезувчанлик билан белгиланади. Тарихий жиҳатдан, пневмокониоз, биринчи навбатда, эркин кристалли силикати билан боғлиқ эди. Бироқ, ҳозирги маълумотлар шуни кўрсатадики, касаллик мураккаб саноат аэрозоллари билан биргаликда ёки синергик таъсир қилиш натижасида ҳам пайдо бўлиши мумкин. Ушбу аэрозоллар фиброген, токсик, аллерген ва тирнаш хусусияти берувчи компонентларни ўз ичига олиши мумкин, бу касалликнинг клиник кўринишларининг хилма-хиллигига ва гетерогенликга ёрдам беради. Ривожланаётган бу тушунча касбий муҳитда илғор ташхис қилиш ёндашувлари ва кенг қамровли профилактика стратегиялари зарурлигини таъкидлайди.

Современные подходы к диагностике и профилактике пневмокониоза в гигиене труда

Ключевые слова:
профессиональные заболевания,
пневмокониоз,
промышленные аэрозоли,
методы диагностики,
клиническая оценка,
патология дыхательной системы,
профессиональное воздействие,
профилактика.

АННОТАЦИЯ

Пневмокониоз остается серьезной проблемой профессионального здоровья, связанной с длительным воздействием промышленных аэрозолей и токсичных веществ. Установлено, что развитие патологических изменений в легочной ткани определяется множеством факторов, включая продолжительность и интенсивность воздействия, физико-химические свойства и концентрацию вдыхаемых частиц, а также индивидуальную восприимчивость. Исторически пневмокониоз преимущественно связывали с вдыханием пыли, содержащей свободный кристаллический диоксид кремния. Однако современные данные указывают на то, что заболевание может также возникать в результате комбинированного или синергического воздействия промышленных аэрозолей сложного состава. Эти аэрозоли могут включать фиброгенные, токсичные, аллергенные и раздражающие компоненты, что способствует разнообразию клинических проявлений и гетерогенности заболевания. Это развивающееся понимание подчеркивает необходимость в передовых диагностических подходах и комплексных профилактических стратегиях в профессиональной среде.

In modern pulmonology distinguish chronic occupational diseases of lungs in which etiology the leading place is taken by dust content and gas contamination of air of a working zone and leading to development of a connecting tissue, that is diffuse primary fibrosis – to a pneumoconiosis. A pneumoconiosis in structure of the existing occupational diseases is high on the list and generally meets in the coal-mining, asbestos, mechanical, glass engineering industry [4, 8, 9].

It is established that industrial aerosols and toxic substances which effect leads to development of pathological changes are the reason of development of a pneumoconiosis and depends on duration of influence, their structure, quantity and also individual predisposition of an organism [1, 2, 7]. Mistakenly very long time was considered that the pneumoconiosis causes only the dust containing free silicon dioxide. However, now it is proved that this occupational disease can arise under the complex or combined action of the industrial aerosols of complex structure including substances fibrogenny, toksik-dust and allergenic, sensitizing and irritant action that caused body height of a pneumoconiosis [3, 5, 6], not characteristic of classical forms, in recent years, as served as the purpose for carrying out this research.

Accounting of a professional route of the patient and identification of possible contacts to production dust during all work is of particular importance. Among clinical diagnostic testing there is widely known large personnel roentgenophotography which is a starting point at diagnosis which taps characteristic intensifying and deformation of the pulmonary drawing, existence of fine focal shadows. Such researches as roentgenography of lungs, a computer tomography, a magnetic resonant tomography of lungs allows to specify a pneumoconiosis form (an interstitial, nodous, nodal form) and a disease stage. The existing methods of a spirometry and a gas analytical research allow to conduct researches of function of external respiration and to define borders of changes in pulmonary tissues. Not unimportant value also the microscopical research of a sputum, a bronchoscopy, etc. gets modern methods. Thus, for diagnosis there is a large number of methods, both traditional, and new modern methods with use of the highly sensitive equipment [10].

In contemporary pulmonology, chronic occupational lung diseases represent a significant medical and socio-economic challenge, particularly those associated with prolonged exposure to industrial aerosols and gaseous pollutants in the workplace environment. Among these conditions, pneumoconiosis is characterized by diffuse interstitial fibrosis resulting from the inhalation and deposition of mineral and organic dust particles. This pathology occupies a leading position within the structure of occupational diseases and is predominantly observed in industries such as coal mining, asbestos processing, mechanical engineering, and glass manufacturing.

The pathogenesis of pneumoconiosis has been extensively studied, and it is now well established that the disease develops as a consequence of long-term exposure to industrial aerosols and toxic substances capable of inducing persistent inflammatory and fibrotic changes in pulmonary tissue. The severity, clinical course, and progression of pneumoconiosis are determined by multiple factors, including the duration and intensity of exposure, physicochemical properties and concentration of inhaled particles, as well as individual biological susceptibility. Historically, pneumoconiosis was primarily associated with exposure to crystalline silica dust. However, recent scientific evidence has demonstrated that this disease may arise from the combined or synergistic effects of complex industrial aerosols containing fibrogenic, toxic, allergenic, sensitizing, and irritant components. Such multifactorial exposure contributes to the emergence of atypical and clinically heterogeneous forms of pneumoconiosis, which differ from classical variants in their morphological and functional manifestations. This evolving understanding underscores the necessity for continued research into modern diagnostic and preventive strategies.

The present study is focused on the analysis of contemporary diagnostic approaches to pneumoconiosis, considering the growing availability of highly sensitive and specific investigative techniques that enable early detection and accurate characterization of the disease. These advancements are essential for the timely implementation of preventive, therapeutic, and rehabilitation measures.

Despite significant technological progress, the role of traditional sanitary-hygienic assessment of working conditions remains indispensable. A comprehensive evaluation of occupational exposure – including the qualitative composition of dust, duration of exposure, and concentrations exceeding permissible exposure limits – continues to serve as a fundamental component in establishing the etiological basis of pneumoconiosis. Particular importance is attributed to the detailed assessment of the patient's occupational history, which allows for the identification of cumulative exposure to hazardous industrial dust over the course of employment. Among primary screening methods, mass fluorographic examination retains its diagnostic relevance, serving as an initial tool for detecting characteristic radiological features, such as усиление и деформация легочного рисунка and the presence of small nodular opacities. Further diagnostic clarification is achieved through advanced imaging modalities, including chest radiography, high-resolution computed tomography (HRCT), and magnetic resonance imaging (MRI), which facilitate precise differentiation of pneumoconiosis forms (interstitial, nodular, and mixed) and staging of disease progression. Functional assessment of the respiratory system is conducted using spirometry and gas exchange analysis, enabling the evaluation of ventilatory capacity and the extent of pulmonary dysfunction.

Additional diagnostic methods, such as sputum microscopy, bronchoscopy, and other minimally invasive procedures, contribute to a comprehensive evaluation of patients. The integration of traditional and modern high-sensitivity diagnostic tools ensures a multifaceted approach to the detection and monitoring of pneumoconiosis. According to contemporary literature, the structural characteristics of pneumoconiosis are largely determined by the composition and fibrogenic potential of industrial aerosols. Notably, approximately 58.8% of silicosis cases are associated with exposure to aerosols exhibiting moderate to high fibrogenic activity, which correlates with distinct clinical and radiological patterns.

A comprehensive assessment of clinical, radiological, functional, and laboratory parameters, combined with longitudinal patient monitoring, provides a robust basis for determining optimal management strategies. These include individualized therapeutic interventions, rehabilitation programs, and informed decisions regarding patients' occupational suitability and further employment.

Preventive measures constitute the cornerstone of occupational health strategies aimed at reducing the incidence of pneumoconiosis. Key interventions include the optimization of working conditions, strict compliance with occupational safety regulations, modernization of technological processes, implementation of effective local exhaust ventilation systems, environmental humidification, and the consistent use of personal protective equipment. The integration of these measures is essential for minimizing occupational exposure and mitigating the long-term health consequences associated with industrial dust inhalation.

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