

R.V. Rubtsov**VALUE OF ROENTGENOLOGIC EXAMINATION IN DIAGNOSTICS OF PNEUMOCONIOSIS ASSOCIATED WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE IN WORKERS OF MINING AND METALLURGICAL INDUSTRY***SI «Ukrainian Research Institute of Industrial Medicine»**Vinogradov str., 40, Kryvyi Rih, Dnipropetrovsk region, 50096, Ukraine**e-mail: ndiprommed@gmail.com**ДУ «Український науково-дослідний інститут промислової медицини»**вул. Виноградова, 40, Кривий Ріг, Дніпропетровська обл., 50096, Україна***Цитування:** *Медичні перспективи. 2019. Т. 24, № 1. С. 66-72***Cited:** *Medicni perspektivi. 2019;24(1):66-72***Key words:** *pneumoconiosis, chronic obstructive pulmonary disease, radiography, chest organs***Ключові слова:** *пневмоконіоз, хронічне обструктивне захворювання легень, рентгенографія, органи грудної клітки***Ключевые слова:** *пневмокозиоз, хроническое обструктивное заболевание легких, рентгенография, органы грудной клетки*

Abstract. *Value of roentgenologic examination in diagnostics of pneumoconiosis associated with chronic obstructive pulmonary disease in workers of mining and metallurgical industry. Rubtsov R.V. The aim of the research is to study the peculiarities of changes in the chest organs on the plain radiograph in pneumoconiosis associated with COPD in workers of mining and metallurgical industry. The data of clinical examination of 635 workers with lung pathology of occupational genesis are presented in the article. Group I consisted of 99 workers with pneumoconiosis associated with COPD, group II – of 21 workers with pneumoconiosis, and group III – of 515 workers with COPD of occupational etiology. A comparative analysis of radiographic changes in the chest X-ray has established that the most informative radiologic changes for pneumoconiosis associated with COPD are: linear reticular blackening up to 1.5 mm in size, cord-like blackening from 1.5 to 3.0 mm in size, and less significant changes in the form of nodules up to 1.5 mm in size, from 1.5 to 3.0 mm, thickening of pleura more than 10.0 mm in width. The most sensitive radiographic signs typical for PC associated with COPD are the indicated blackenings and nodules, their etiological share in diagnosis of this disease is 100%, determining the greatest absolute risk of development of this occupational pathology in this category of patients. The revealed X-ray diagnostic criteria allow to conduct timely diagnostics, define the tactics of treatment and prevention of PC associated with COPD in workers of mining and metallurgical industry.*

Реферат. *Значимість рентгенологічних досліджень при діагностиці пневмокозиоза в поєднанні з хронічним обструктивним захворюванням легких у робочих горнорудної і металургічної промисловості. Рубцов Р.В. Цель исследования – изучить особенности изменений органов грудной клетки на обзорной рентгенограмме при пневмокозиозе в сочетании с ХОЗЛ у рабочих горнорудной и металлургической промышленности. В статье представлены данные клинического обследования 635 рабочих с патологией легких профессиональной этиологии: I-я группа – 99 рабочих с пневмокозиозом в сочетании с ХОЗЛ, II-я группа – 21 рабочий с пневмокозиозом и III-я группа – 515 рабочих с ХОЗЛ профессиональной этиологии. Проведен сравнительный анализ рентгенологических изменений органов грудной клетки на обзорной рентгенограмме легких. Установлено, что для пневмокозиоза в сочетании с ХОЗЛ наиболее информативными рентгенологическими изменениями на современном этапе являются: наличие линейных сетчатых затемнений размером до 1,5 мм, тяжистых затемнений размером от 1,5 до 3,0мм, а также менее значимых изменений в виде узелков размером до 1,5 мм, от 1,5 до 3,0 мм, утолщения плевры шириной более 10,0 мм. Наиболее чувствительными рентгенологическими признаками, характерными для ПК в сочетании с ХОЗЛ, являются указанные затемнения и узелки, их этиологическая доля при диагностике данного заболевания составляет 100%, определяя наибольший абсолютный риск развития данной профессиональной патологии у этой категории больных. Выявленные рентгенологические диагностические критерии позволяют проводить своевременную диагностику, определять тактику лечения и профилактики ПК в сочетании с ХОЗЛ у рабочих горнорудной и металлургической промышленности.*

In recent years, dusty diseases of the lungs are the most common form of occupational diseases among workers in the mining and metallurgical industry and present an urgent medical and social problem [8]. Types of this pathology in modern conditions are determined, mainly, by two nosological forms: pneumoconiosis (PC) and chronic obstructive pulmonary disease (COPD). Undoubtedly, this determines the urgency of dealing with the problem of the timely diagnosis, treatment and prevention of these diseases among industrial workers [8, 11].

The successes that have been achieved in solving this problem in recent years are connected, on the one hand, with the introduction of anti-dust measures in the mining and metallurgical enterprises, and, on the other hand, by conducting modern molecular genetic studies aimed at the phenotyping of these diseases, which allowed to expand the idea of pathogenetic mechanisms of their formation and course [4, 8].

It should be noted that to date, there is no single approach to the definition of PC and COPD of professional etiology. The first of them considers these diseases as separate nosological forms of the respiratory system, the second – as a disease with unique pathogenetic mechanisms, and from here COPD is considered as one of the clinical forms of PC [6].

However, the main method of diagnostics of the PC to date is a plain radiograph of the chest cavity (PRC), this method can detect not only signs characteristic of the PC, as well as make differential diagnosis with other pathological states in the lungs of sick workers [2, 3, 5, 7].

Undoubtedly, when PC is combined with COPD, plain radiography significantly expands the diagnostic capabilities of these diseases, provides an opportunity to determine the characteristic radiological signs inherent in this category of sick workers. The current state of representations of occupational diseases of the lungs in the mining and metallurgical industry requires the definition of clinical and radiological criteria for diagnosis of PC in combination with COPD for their timely detection, development of effective measures for treatment and prevention. The lack of data available in literature on X-ray manifestations of PC in combination with COPD in workers of the mining and metallurgical industry, motivated the relevance of the research.

The purpose of the research is to study the peculiarities of changes in the chest cavity on the plain X-ray in workers of the mining and metallurgical industry, patients with pneumoconiosis in combination with COPD.

MATERIALS AND METHODS OF RESEARCH

The survey included 635 employees of mining and metallurgical industry, patients with occupational lung diseases, which were surveyed at the clinic of UkrDipromMed SD over the period of 2012-2015. Of these, there were 99 patients with PC in combination with COPD, 21 patients with PC and 515 patients with COPD of professional etiology. The average age of workers was $58,6 \pm 2.4$ years, the work experience in unfavorable conditions – 18.9 ± 0.8 years. Diagnosis of PC was established in accordance with the X-ray classification adopted by the International Labor Organization (ILO) in 1980 and the methodological recommendations "Application of the classification of pneumoconioses in Ukraine" (Kyiv, 2003). The diagnosis of COPD was established on the basis of International GOLD Criteria, as well as the Order of the Ministry of Health of Ukraine of June 27, 2013, N 555 "On Approval and Implementation of Medical-Technological Documents for the Standardization of Medical Care in Case of Chronic Obstructive Pulmonary Disease" [3, 9, 12].

X-ray examinations of the chest cavity were performed on the X-ray unit TUR-700 (USSR) in a frontal projection, standing up, on a deep breath in. Power generator: 240-700 m at 70-125 kW. Nominal short-term strength: 47.5 kW. Nominal long-term strength: 300 W/h. Exposure for shooting mode – 0.01-10 sec. The following features were evaluated: interstitial forms of pneumofibrosis (linear and reticular) up to 1.5 mm (s) wide, cord-like – 1.5 to 3.0 mm wide (t), rough cord-like changes from 3 to 10 mm (u) in width; nodular forms: small rounded blackenings to 1.5 mm (p) in size, from 1.5 to 3.0 mm (q), from 3.0 to 10.0 mm (r). Sharpness of the contours, their localization, as well as the density of changes: category 1 – a few nodular and interstitial changes on the background of a preserved pulmonary pattern, category 2 – numerous changes in the interstitial form, when the pulmonary pattern is practically not defined or nodular shape against the background of a preserved pulmonary picture, category 3 – numerous small dense or expressed linear (reticular) fibrous changes that deform the pulmonary pattern and it is not determined. Node forms: from 10.0 to 50.0 mm – minute-nodular (A), more than 50 mm, but less than 1/3 right lung area – large (B), more than 1/3 of the right lung area – massive (C) Thickening of the pleura: the width is less than 5.0 mm – "A", from 5.0 to 10.0 mm – "B", more than 10.0 mm – "C", as well as its area of its distribution: less than 1/4 of parietal part of the

pleura – 1, from 1/4 to 1/2 – 2, more than 1/2 of parietal part of the pleura – 3. The presence of other x-ray changes in the lungs was taken into account: enlargement and induration of the root lymph nodes (hi), their calcification (cs), emphysema of the lungs (em), bullous emphysema (bu), changes in the size of the heart (co) signs of pulmonary heart (sr), pneumothorax (px), tuberculosis (tb), lung cancer (ca), rheumatoid pneumoconiosis (rp), cavity (cv), Kerley lines (ah), honeycomb lungs" (ho).

According to the results of the conducted studies, the prevalence of the signs (pr) was determined by the formula:

$$pr = (a + c) / N \quad (1)$$

where: a - the number of patients with the sign in the experimental group, c - the number of patients with the sign in the comparison group, N - the total number of patients examined.

Taking into account the most significant radiological signs characteristic of PC in combination with COPD according to the international method [10], the absolute risk (AR) (AR – probability of occurrence of the sign in the experimental group, AR₀ – probability of occurrence in the comparison group), which was defined as the ratio of the number of persons with this sign to the size of the experimental group, sensitivity (Se) – the probability of detecting the influence of the harmful factor) by the formula:

$$Se = a / (a + c) \quad (2)$$

Relative Risk (RR) as the ratio of AR / AR₀ and its confidence interval (95% CI) by the formulas:

$$RR_{min} = \exp [\ln (RR) - 1.96 ((c / ((a + c) * a)) - (d / (b * (b + d)))^{0.5})] \quad (3)$$

$$RR_{max} = \exp [\ln (RR) + 1.96 ((c / ((a + c) * a)) - (d / (b * (b + d)))^{0.5})] \quad (4)$$

where: a – number of persons with the sign, b – number of persons without a mark in the study group, c and d, the same in the comparison group (relative risk was considered statistically significant if RR_{min} is more than unity), the etiological proportion of relative risk (EF), which was calculated by the formula:

$$EF = (RR - 1) / RR * 100\% \quad (5)$$

The reliability ratio was determined by odds ratio of appearance of the sign OR = ad / (cb) and its confidence interval:

$$\text{lower limit (95\% CI)} = e^{\log(OR) - 1.96 \cdot \sqrt{\frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \frac{1}{d}}} \quad (6)$$

$$\text{upper limit (95\% CI)} = e^{\log(OR) + 1.96 \cdot \sqrt{\frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \frac{1}{d}}} \quad (7)$$

where is the radical – radical, e-basis of natural logarithm, constant, which is equal to 2.718281828.

RESULTS AND DISCUSSION

The analysis of the prevalence (pr) of radiological signs inherent to PC was made to determine informative radiological parameters (table 1). The given data indicate that the workers of mining and metallurgical industry, patients with PC in combination with COPD, have changes mainly in the lungs, in the form of linear reticular blackenings in the size of up to 1.5 mm. The prevalence of this sign is 7.2 times more than of the similar cord-like blackenings in the size from 1.5 to 3.0 mm, and by 31.3 times than of the same changes in the size from 3.0 to 10.0 mm. In the comparison group (patients with PC and COPD of professional etiology) the prevalence of these signs is much less: reticular blackenings in the size to 1.5 mm – by 5.2 times, cord-like in the size from 1.5 to 3.0 mm – by 6,5 times, and in the size from 3,0 to 10,0 mm – by 1,87 times.

The prevalence (pr) of nodules in patients with PC in combination with COPD was the greatest if they were up to 1.5 mm in size. It was larger than the nodules in the size from 1.5 to 3.0 mm by 1.5 times and was not detected in any case in the size from 3.0 to 10.0 mm. Comparing the pr of this sign to patients with PC and COPD of professional etiology, it was found that nodules up to 1.5 mm were found to be 4.3 times more often, and in the size from 1.5 to 3.0 mm – by 3.6 times. It should be noted that nodules of size from 3.0 to 10.0 mm were found only in some patients in the comparison group.

The prevalence of pleural thickening in patients with PC in combination with COPD was greater at a width of more than 10.0 mm. Its pr was larger than similar changes in width from 5.0 to 10.0 mm by 1.7 times and to 5.0 mm – by 2.5 times. Comparing the pr of this sign to patients with PC and COPD of professional etiology, it was found that in PC combined with COPD thickening of the pleura in width up to 5.0 mm, this figure was 4.5 times larger, from 5,0 to 10.0 mm, on the contrary, smaller by 3.27 times and width more than 10.0 mm – smaller by 5.6 times.

Table 1

**Prevalence of X-ray signs in workers of mining and metallurgical industry,
patients with occupational lung diseases**

Sign	Size	Prevalence of sign (pr)	
		patients with pneumoconiosis combined with COPD (n=99)	patients with other occupational lung pathology (n=536)
Linear blackenings	to 1.5mm	0.94	0.18
Cord-like	from 1.5 to 3.0 mm	0.13	0.02
	from 3.0 to 10.0 mm	0.03	0.016
Nodules	to 1.5 mm	0.06	0.014
	from 1.5 to 3.0 mm	0.04	0.011
	from 3.0 to 10.0 mm	0.0	0.002
Pleura thickening	to 5.0 mm	0.02	0.004
	from 5.0 до10.0 mm	0.029	0.095
	more than 10.0 mm	0.05	0.28

An in-depth risk-metric analysis of the diagnostic value of the aforementioned X-ray changes in the lungs showed (table 2), that in patients with PC in combination with COPD, the most significant signs with the highest sensitivity (se) were linear reticular blackening up to 1.5 mm, cord-like ones – from 1.5 to 3.0 mm, nodules – up to 1.5 mm and from 1.5 to 3.0 mm, pleural thickening up to 5.0 mm (from 0.67 to 1.0). It was found that in this category of patients, the etiological part of the effect (EF) of the combined form of the disease was the highest for such radiological signs: linear reticular and cord-like blackening, nodules, and thickening of the pleura up to 5.0 mm (from 90.7 to 100.0%) Thickenings of the pleura from 5.0 to 10.0 mm and more than 10.0 mm in width, though with a significant percentage of EF, but its value was much lower when compared to other previously given X-ray signs. The assessment of chances (OR) to find the given radiological sign in the diagnosis of patients with PC in combination with COPD showed, that the presence of linear reticular up to 1.5 mm and cord-like from 1.5 to 3.0 mm blackenings, as well as nodules up to 1.5 mm and from 1.5 to 3.0 mm is observed only in patients with PC in combination with COPD. The impact of the combined form on the thickness of the pleura of varying widths is less significant, but nevertheless the chances of the appearance of this sign are significantly higher (by 3.1-11.1 times ($p<0.05$)) in a combined course of these diseases than in PC and COPD of professional etiology.

Comparing the chances of developing X-ray signs inherent in a PC in combination with COPD, in relation to patients with COPD of professional etiology or to patients with PC (table 3), the following was found: when compared to COPD patients of professional etiology, linear reticular blackenings up to 1,5 mm and cord-like ones from 1.5 to 3.0 mm were specific only for the combined course of these diseases. The overall probability of occurrence of these radiological signs was the highest and was characterized by a significant difference from patients in the comparison group ($p<0.05$). The presence of nodules of all gradations (sizes) was also characteristic of patients with PC in combination with COPD. The overall likelihood of their occurrence, when compared to patients with COPD of professional etiology, indicated their absolute specificity for this combined professional pathology of the lungs. Thickening of the pleura to 5.0 mm also was characteristic only for patients with PC in combination with COPD. It should be noted that the chances of thickening of the pleura from 5.0 to 10.0 mm in this category of patients, when compared to patients with COPD of professional etiology, are significantly higher ($p<0.05$). This can not be asserted in relation to the pleural thickening of more than 10.0 mm, the chances here are almost equal. Generally, the chances of detecting pleural thickening in patients with PC in combination with COPD are significantly higher ($p<0.05$) than in patients with COPD of professional etiology.

Table 2

Diagnostic value of radiological signs in workers of mining and metallurgical industry, patients with pneumoconiosis in combination with COPD

Sign	Range of assessment of X-ray sign	Parameters of risk		
		sensitivity Se	etiologic share of impact on EF manifestation sign	odds ration OR±m and its confidential interval
		0-1,0	0-100,0%	times
Linear blackenings	to 1.5 mm	1.0	100%	Observed only in patients with PC combined with COPD
Cord-like	from 1.5 to 3.0 mm	1.0	100%	Observed only in patients with PC combined with COPD
	to 1.5 mm	1.0	100.0%	Observed only in patients with PC combined with COPD
Nodules	from 1.5 to 3.0 mm	1.0	100.0%	Observed only in patients with PC combined with COPD
Pleura thickening	Width to 5.0 mm	0.67	90.7%	11.1±1.2* (1-118)
Pleura thickening	Width from 5.0 to 10.0 mm	0.31	59.1%	3.1±0.2* (1.8-5.0)
Pleura thickening	Width more than 10.0 mm	0.38	69.1%	3.4±0.5* (1.2-9.2)

Notes: * - reliable (p < 0.05); m-error

Characterizing the odds ratio of appearance of X-ray signs inherent in a PC in combination with COPD, when compared to patients with PC, it was established that with a combined course of these diseases, the presence of cord-like blackenings in the size from 1.5 to 3.0 mm was specific. The likelihood of changes in the lungs in the form of linear reticular blackenings of up to 1.5 mm and cord-like ones from 3.0 to 10.0 mm is more common in patients with PC. It should be noted that the risk of the appearance of blackenings in the group of patients with PC in combination with COPD is not statistically different from patients with PC. By evaluating another radiological sign, nodules, it was found that for patients with PC in combination with COPD, the OR index of these formations in the lungs was extremely low. This indicates that this symptom is more common in patients with PC than patients with PC in combination with COPD. In general, the chances of nodes development were significantly higher in patients with PC. The chances of detecting pleural thickening in patients with PC in combination with COPD, when compared to patients with PC, were greatest when the thickness was more

than 10.0 mm in width. The same chances were to detect pleural thickening from 5.0 to 10.0 mm in width and greater chances to detect of pleural thickening up to 5.0 mm in the group of patients with PC. In general, the chances of detecting pleural thickening in patients with PC in combination with COPD were the same as in patients with PC.

Consequently at present, in workers of mining and metallurgical industry, patients with PC in combination with COPD, the most likely changes in the lungs on the roentgenogram of the chest cavity, which determine the risks of this occupational lung disease are: the presence of linear reticular blackenings to 1.5 mm and cord-like blackenings from 1.5 to 3.0 mm. The less common and significant signs are nodules in the lungs up to 1.5 mm and 1.5 to 3.0 mm, as well as thickening of the pleura more than 10.0 mm in width. It should be noted that the blackenings and nodules have the highest sensitivity to the combined PC and COPD course, their etiologic share is 100%. So, these x-ray signs determine the highest absolute risk of this occupational lung pathology in this category of patients.

Table 3

Characteristics of risk of developing X-ray signs in workers of mining and metallurgical industry, patients with pneumoconiosis combined with COPD

Sign	Range of assessment of X-ray sign	Odds ration OR±m and its confidential interval (95% CI)	
		in patients with PC combined with COPD as related to patients with COPD of occupational etiology	in patients with PC combined with COPD as related to patients with COPD
Linear reticular blackenings	to 1.5 mm	Observed only in patients with PC combined with COPD	0.8±1.1 (0.09-6.8)
Cord-like blackenings	from 1.5 to 3.0 mm	Observed only in patients with PC combined with COPD	Observed only in patients with PC combined with COPD
	from 3.0 to 10.0 mm	2.7±0.7 (0.7-10.8)	0.3±0.9 (0.05-2.0)
Risk of blackening appearance		2015±0.7* (557-7275)	1.2±1.1 (0.1-11.2)
Nodules	to 1.5 mm	Observed only in patients with PC combined with COPD	0.4±0.8 (0.09-1.7)
	1.5-3 mm	Observed only in patients with PC combined with COPD	0.3±0.8 (0.05-1.2)
	3-10 mm	Observed only in patients with PC combined with COPD	Was not observed in patients with PC combined with COPD
Risk of nodules appearance		Observed only in patients with PC combined with COPD	0.2±0.6 (0.07-0.7)
Pleura thickening	to 5.0 mm	Observed only in patients with PC combined with COPD	0.4±1.2 (0.04-4.8)
	from 5.0 to 10.0 mm	3.3±0.2 * (2.0-5.6)	0.8±0.5 (0.3-2.3)
	more than 10.0 mm	2.1±0.5 (0.7-5.9)	Observed only in patients with PC combined with COPD
Risk of pleura thickening		3.4±0.2* (2.1-5.6)	0.9±0.5 (0.3-2.2)

CONCLUSIONS

1. According to the results of the study, it has been found that at the present stage, in workers of mining and metallurgical industry, patients with PC in combination with COPD, the most characteristic x-ray changes in the lungs are linear reticular blackenings of 1.5 mm in size, cord-like ones from 1.5 up to 3.0 mm in size, nodules with the size of 1.5 mm and 1.5 to 3.0 mm, as well as thickening of the pleura more than 10.0 mm wide.

2. The most significant radiological signs that determine the risk of developing PC in combination with COPD are linear reticular blackenings and cord-like ones in of 1.5 mm and 1.5 to 3.0 mm, as well as thickening of the pleura greater than

10.0 mm in width, the odds ratio of occurrence of which is absolute or close to it in this category of patients.

3. Evaluation of x-ray symptoms in PC in combination with COPD in workers of mining and metallurgical industry is the main and most informative criterion for the diagnosis of this occupational pathology of lungs in this category of patients.

4. The revealed radiological signs in PC in combination with COPD are the basis for defining the recommendations for the rational employment of sick workers outside the influence of industrial pollutants and the introduction of measures for the treatment and prevention of the disease.

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The article was received
2018.11.29

