

6. Gross M. [Liver cirrhosis and the most common complications: diagnosis and treatment]. MMW Fortschr Med. 2015 Mar 26;157 Suppl 1:75–9. doi: 10.1007/s15006-015-2550-3. Review. German. PubMed PMID: 26012993.
7. Hernández-Gea V, Berbel C, Baiges A, García-Pagán JC. Acute variceal bleeding: risk stratification and management (including TIPS). Hepatol Int. 2018 Feb; 12(Suppl 1):81–90. doi: 10.1007/s12072-017-9804-3. Epub 2017 Jun 20. Review. PubMed PMID: 28634688.
8. Higuera-de-la-Tijera F, Servín-Caamaño AI, Salas-Gordillo F, Pérez-Hernández JL, Abdo-Francis JM, Camacho-Aguilera J, Alla SN, Jiménez-Ponce F. Primary Prophylaxis to Prevent the Development of Hepatic Encephalopathy in Cirrhotic Patients with Acute Variceal Bleeding. Can J Gastroenterol Hepatol. 2018 Jul 10;2018:3015891. doi: 10.1155/2018/3015891. PMID: 30079329; PMCID: PMC6069577.
9. Moctezuma Velázquez C, Abraldes JG. Non-invasive diagnosis of esophageal varices after Baveno VI. Turk J Gastroenterol. 2017 May;28(3):159–165. doi: 10.5152/tjg.2017.16744. Review. PubMed PMID: 28492370.
10. Petrusenko VV, Hrebenuk DI, Radoha YV, Tsyhalo DV, Melnychuk MO, Dorozhynskiy YA, Tatarin AY. Prevention of bleeding in patients with portal hypertension syndrome. Medicni perspektivi. 2018; 23(4):164–165.
11. Sidhu SS, Sharma BC, Goyal O, Kishore H, Kaur N. L-ornithine L-aspartate in bouts of overt hepatic encephalopathy. Hepatology. 2017 Jul 27. doi: 10.1002/hep.29410. [Epub ahead of print] PubMed PMID: 28749571.
12. Tayyem O, Bilal M, Samuel R, Merwat SK. Evaluation and management of variceal bleeding. Dis Mon. 2018 Jul; 64(7):312–320. doi: 10.1016/j.disamonth.2018.02.001. Epub 2018 Mar 7. Review. PubMed PMID: 29525376.
13. Tsochatzis EA, Bosch J, Burroughs AK. Liver cirrhosis. Lancet. 2014 May 17; 383(9930):1749–61. doi: 10.1016/S0140-6736(14)60121-5. Epub 2014 Jan 28. Review. PubMed PMID: 24480518.
14. Zhou WC, Zhang QB, Qiao L. Pathogenesis of liver cirrhosis. World J Gastroenterol. 2014 Jun 21;20(23):7312–24. doi: 10.3748/wjg.v20.i23.7312. Review. PubMed PMID: 24966602; PubMed Central PMCID: PMC4064077.

Стаття надійшла 15.03.2020 р.

DOI 10.26724/2079-8334-2021-2-76-117-121

UDC 57.083.3:616:23/24

N.O. Pylypenko, E.Ya. Nikolenko, K.V. Vovk, O.G. Reznichenko, G.S. Kratenko, S.V. Gridnieva,
M.V. Martynenko, V.V. Pilipenko¹
V.N. Karazin Kharkiv National University, Kharkiv, ¹Poltava Applied Oil and Gas College
of National University, ²“Yuri Kondratyuk Poltava Polytechnic”, Poltava

THE STATE OF BLOOD INDICES IN THE FOUNDRY WORKERS

e-mail: npylypenko.kharkiv@gmail.com

The study of hematological parameters of 42 healthy people who have been working for more than ten years under the influence of dust-forming factors of production environment, among which silicon dioxide dominates, revealed: redistribution of white blood cell percentage; changes in erythrocyte membrane permeability; reduced blood clotting time; erythrocyte sedimentation rate; significant differences compared with control values of integral indices. Such changes are likely to have an adaptive focus, however – with continued contact of the subjects with the harmful factor, such changes can become markers of the development of disorders of innate immunity, with a subsequent risk of occupational chronic bronchopulmonary diseases.

Key words: industrial dust, hematological indices, markers of inflammatory processes.

**Н.О. Пилипенко, Є.Я. Ніколенко, К.В. Вовк, О.Г. Резніченко, Г.С. Кратенко, С.В. Гріднєва,
М.В. Мартиненко, В.В. Пилипенко**

СТАН ПОКАЗНИКІВ КРОВІ У ОСІБ, ЯКІ ПРАЦЮЮТЬ В УМОВАХ ПИЛОУТВОРЮЮЧИХ ВИРОБНИЦТВ

За результатами вивчення гематологічних показників 42 практично здорових осіб, які більше десяти років працювали в умовах впливу пилоутворюючих факторів виробничого середовища, серед яких домінував діоксид кремнію, було виявлено перерозподіл відсоткового вмісту клітин білої крові, зміни проникності еритроцитарних мембран, скорочення часу згортання крові, збільшення швидкості осідання еритроцитів та достовірні відмінності в порівнянні з контрольними значеннями показників інтегральних індексів. Такі зміни, вірогідно, мають адаптаційну спрямованість, однак, при продовженні контакту обстежуваних зі шкідливим фактором можуть стати маркерами розладів з боку природженого імунітету, з подальшим ризиком розвитку професійних хронічних бронхолегеневих захворювань.

Ключові слова: виробничий пил, гематологічні індекси, маркери запальних процесів.

This work is a fragment of the research project “Investigation of the cognitive mechanisms of selective attention at different stages of learning using a model object”, state registration No. 0119U103673.

Incidence of occupational etiology, as part of morbidity of the working population, has social significance for a number of countries, regardless of their level of economic development [2]. In Ukraine, occupational morbidity also remains a complex hygienic and socio-economic problem [4], in particular mechanical engineering is ranked second after coal industry in terms of contribution to the pool of occupational morbidity [5].

High risk of developing diseases of the bronchopulmonary system is inherent in workers who are exposed to the complex effects of harmful factors – industrial aerosols, fibrogenic dust, adverse microclimate, and high level of work load.

The most common occupational pathology in workers in mining and metallurgical industries is chronic obstructive pulmonary disease (COPD) and pneumoconiosis (PC) [9]. Dust-forming harmful factors of these industries complicate the course of comorbidities [13]. Bronchopulmonary system is extremely sensitive to industrial abiotic factors, so in direct professional contact with dust, bronchopulmonary system is subjected to significant stress, which further contributes to adverse changes in functioning of other body systems, especially circulatory and immune systems [12]. According to published data sources, the following changes were observed in patients with COPD of occupational etiology: changes in hematological parameters and coagulation systems; imbalance in the ratio of cellular composition of the immune system and integration indices for assessing immune status [10, 11].

Search for ways to reduce the risk of occupational bronchopulmonary diseases has economic, social and scientific vectors. Therefore, studies of prenosological conditions of persons working under the influence of high concentrations of industrial dust are certainly relevant, as their results can be used to implement measures to prevent the development of bronchopulmonary diseases of occupational etiology [14].

The purpose of the work was to study the direction of changes in hematological parameters in persons working under the influence of dust-forming production, and to determine the possibility of using these indicators as markers of inflammatory processes.

Materials and methods. 42 persons (main group) were examined – the employees of main specialties of Kharkiv machine-building enterprises with 11–20 years of work experience with impact of the harmful factors, the dominant of which was the high concentration of dust containing SiO_2 in the air of the working area. The control group included 30 practically healthy individuals who did not come into contact with harmful factors of dust-forming production and did not have diseases of the respiratory system. The average age of the persons from the control group and the research group was 40.5 and 43.8 years respectively.

The studies were carried out on 9.5 ml of biological material (blood), which was taken on an empty stomach from the ulnar vein. Methods used in the research: cytological method for studying hematological parameters; spectrophotometric method for determining the state of permeability of erythrocyte membranes (PEM) [8]. For the interpretation of the level of adaptive stress of the organism the indices calculated from the leukogram were used: index of approximate assessment of the immune status – Garkavi coefficient (GC) (lymphocytes/segmental neutrophils, norm 0.3–0.6); ratio index of the neutrophils and the monocytes (ISNM, norm 0–36), the index of inflammatory activity $\text{LTESR} = \text{leukocytes} \times \text{erythrocyte sedimentation rate (ESR)} / 10$ (norm up to 4); index of allergy ($\text{IA} = \text{lymphocytes} + 10 \times (\text{eosinophils} + 1) / (\text{band neutrophils} + \text{segmented neutrophils} + \text{monocytes} + \text{basophils})$) (norm 0.79–1.08) [1, 3, 7]. The obtained results were processed by statistical methods of Student–Fisher using the default function set of Microsoft Excel (MS Office 2007). Quantitative indices are presented in the form $M \pm m$, where M is the mean value, m – standard deviation of the mean. The critical significance level in checking statistical hypotheses (p) was assumed to be 0.05.

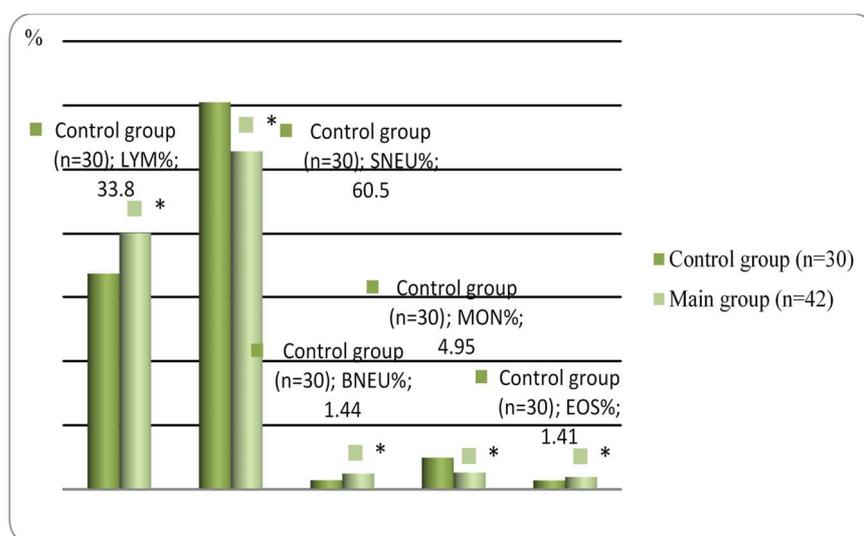


Fig. 1. Leukogram profile of the persons who work in the hazardous working conditions. Note: * – shifts are significant in comparison with the control group ($p < 0.05$)

Results of the study and their discussion.

Under the influence of dust-forming industries, with a predominant content of dust containing SO_2 , risk of development of chronic bronchopulmonary system diseases (COPD and PC) increases. Development of these diseases is known to be associated with immunological disorders and consequently with changes in blood counts. Therefore, in order to identify the initial manifestations of such changes, the point of interest

was to investigate the state of blood parameters in persons who have long been in contact with this production factor.

Figure 1 shows that in persons who work in hazardous dust work zone, redistribution of the percentage of white blood cells was registered on the background of absence of significant changes in total number of leukocytes, compared to the control group (5.91 ± 0.20)/(6.39 ± 0.22).

Thus, in the main group the number of lymphocytes significantly increases (LYM%) by 18.7 % (33.8 ± 1.05)/(40.1 ± 0.86). Relative lymphocytosis is accompanied by a decrease in the percentage of segmental neutrophils (SNEU%) by 12.6 % (60.5 ± 0.81)/(52.7 ± 0.91) in comparison with the control group. These changes can possibly be connected with activation of native immunity, specifically – the phagocytic activity of neutrophils. In addition, a significant increase in the number of band neutrophils (BNEU%) by 72.9 % (1.44 ± 0.04)/(2.49 ± 0.21) was registered in the blood of the main group, which indicates the appearance of immature forms of neutrophils in the blood and thus the activation of hematopoiesis. The decrease in the percentage of monocytes (MON %) (4.95 ± 0.33)/(2.64 ± 0.13) in the blood of the workers by 46.7 % is probably a manifestation of increased migration of these cells into the tissues of the bronchopulmonary system. In addition, in the blood of persons from the main group there was an accumulation of eosinophils (EOS %) (1.41 ± 0.08)/(1.94 ± 0.13), with an increase of 37.6 %.

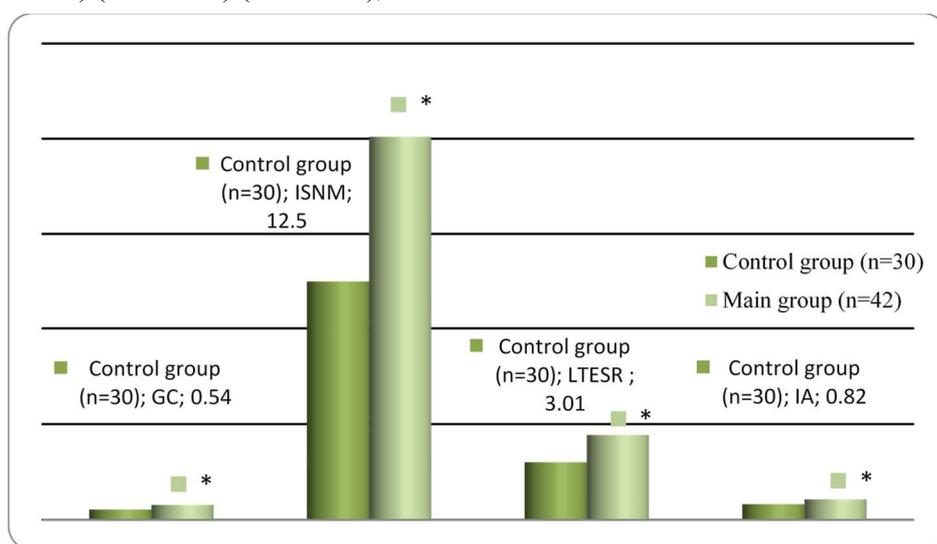


Fig. 2. Integrated indices for assessing inflammation and allergies of people working in hazardous conditions.

Note: * – shifts are significant in comparison with the control group ($p < 0.05$)

GC, which is used to estimate the level of activation of the immune system, in the main group exceeded the upper limit of the normal level (0.3–0.6) and increased by 44.4 % in comparison with the control group (0.54 ± 0.02)/(0.78 ± 0.03). The ISNM that show the ratio in the microphage–macrophage system was significantly increased and exceeded the control values by 60.8 % (12.5 ± 0.9)/(20.1 ± 0.9). The LTESR – index of inflammatory activity in the examined group was 4.43 ± 0.12 , which exceeds normal values and significantly differs in control (3.01 ± 0.18) by 48.5 %. In addition, people who come into contact with quartz dust for 11–20 years had the IA in 30.4 % higher than in the people of the control group (0.82 ± 0.02)/(1.07 ± 0.02).

The study of the red blood cells state also revealed some changes (fig. 3). In the group of workers the ESR is significantly increased (5.15 ± 0.23)/(7.00 ± 0.81), which exceeds the control rate by 35.9 %, and, apparently, affected the index of inflammatory activity.

The study also showed the decrease in the PEM by 37.4 % (18.80 ± 1.45)/(11.76 ± 2.29), which indicates a weakening of the processes of passive filtration of ions through erythrocyte membranes, which may contribute to the deterioration of gas exchange. In addition, compared with the control group, in the group of the workers, blood clotting time was reduced by 22.3 % (3.76 ± 0.15)/(4.84 ± 0.23). This combination of changes in the indicators of red blood cells of people who work in conditions of increased load on the bronchopulmonary system for a long time, can become one of the determining factors in the development of chronic diseases.

In study of the leukogram of persons of the main group, significant changes in the percentage of the main elements of white blood were revealed (LYM %, SNEU %, BNEU %, MON % and EOS %). In order to detect possible risk of developing changes associated with occupational obstructive pulmonary

Quantitative changes in the leukogram of the workers, gave the reason to study integrated indices with involvement of white blood cells profiles. This can help to determine the direction of changes in the state of the blood system and innate immunity of the persons of the main group (fig. 2).

As can be seen from the fig.2, the

disorders, which therefore are related directly to immunological changes. The interest was the increase in individuals of the main group in SNEU % and especially LYM %, since this indicator corresponded to the upper limit of the physiological norm. Comparative analysis with the studies of other authors showed that the direction of the shifts of fore mentioned indices relative to the control group is typical for persons working under conditions of exposure to industrial dust containing SiO₂ [12]; though it differs from the leukogram of persons working under the same conditions, yet having established pulmonary ventilation disorders [7]. However, taking into account the duration of professional contact of the examined persons with a harmful factor, the data obtained suggests an increased risk of a change in adaptive–compensatory processes by disorders in functioning of the immune system.

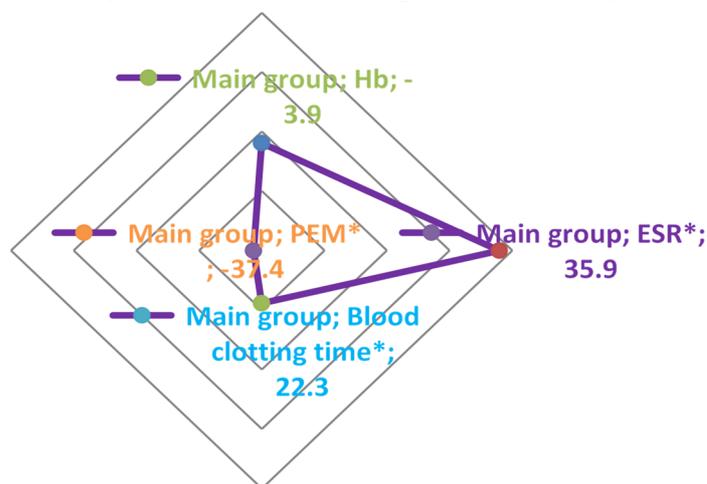


Fig. 3. The state of some indicators of erythron of people working in hazardous conditions (% of the control group).

Note:* – shifts are significant in comparison with the control group ($p < 0.05$)

decrease in the macrophage link indicator – MON %, which increases the probability of activation of a persistent infectious component that accompanies dust load. Activation of the inflammatory process in persons of the main group is confirmed by the excess of the control values of the LTESR by 1.4 times; this orientation, combined with an excess of normal values for this indicator, is a risk factor and is characteristic of persons with diseases of the bronchopulmonary system [6]. Since the level of all elements of the leukogram is taken into account when calculating the IA, its significant difference from the control probably indicates an imbalance in the cellular link of native immunity. Taking into account the exponential nature of the described indices, it can be assumed that the complex of leukocyte indices with the LTESR and the IA can serve as a marker of nonspecific activation and risk of development of inflammatory processes.

The PEM changes, as is known [8], are associated with metabolic rearrangements, in particular, with the intensity of the processes of free radical oxidation of membrane lipid structures. Taking into account the fact that the Hb level in the subjects of the main group did not significantly differ from the control values, the decrease in the PEM in persons of the main group by 1.6 times is probably a reflection of the adaptive mechanisms. However, a long-term impairment of the barrier functions of erythrocyte membranes can contribute to the destruction of their lipid bilayer, a decrease in their elasticity, followed by a violation of the gas transport function of erythrocytes, which, under conditions of dust load on the bronchopulmonary system, can lead to a loss of the adaptive capabilities of these cells. In addition, a decrease in the elasticity of erythrocyte membranes in combination with a decrease in blood clotting time in the examined subjects can most likely affect the rheological properties of blood in general, which, in turn, increases the risk of breakdown of adaptive mechanisms. Thus, the complex of signs of an increased risk of developing inflammatory processes and changes in the rheological properties of blood identified in the study in persons working under conditions of exposure to quartz-containing dust gives grounds for using some of the described indicators as inflammatory markers in monitoring the health of the specified contingent.

Conclusions

1. The nature of changes in the peripheral blood of persons working in conditions of exposure to dust containing quartz for more than 11 years indicates an increased risk of developing immunological disorders.

2. The integral indices of the blood in combination with some indicators of erythron can be used as risk markers of development the inflammatory process in organism of the persons who for a long time contact with the dust containing quartz.

3. Monitoring the condition of aforementioned blood parameters can help identify the risk group of occupational diseases of the respiratory system.

References

- Hodlevskiy AI, Savoliuk SI. Diahnostyka ta monitorynh endotoksykozu u khirurhichnykh khvorykh. Vynnytsia: Nova Knyha. 2015; 232. [in Ukrainian]
- Glyniana LA, Rodionova VV, Gashynova KIy, Chebanov KO, But NO, Bila OI, Mazyrets TA. Struktura promyslovo zmovlenykh zakhvoriuvan u robitnykh metalurhiynoho pidpriemstva, yaki pratsuiut u shkidlyvykh umovakh. Medychni perspektyvy. 2018; 23, 3(1): 60–64. doi: org/10.26641/2307-0404.2018.3(part1).142335. [in Ukrainian]
- Ivchuk VV, Koptieva TYu, Kovalchuk TA. Immunolohichna otsinka aktivnosti zapalnoho protsesu u khvorykh na khronichne obstruktyvne zakhvoriuvannya legen profesiinoyi etiolohiyi. Svit medytsunu ta biolohiyi. 2019; 4 (70): 82–87. doi: 10.26724/2079-8334-2019-3-69-82-87. [in Ukrainian]
- Kundiyeu YuI, Nagorna AM. Profesiyna zakhvoriuvanist v Ukrayini u dynamisti dovhostrokvoho sposterezhennia. Ukrainskyi zhurnal z problem medytsyny pratsi. 2010; 1: 3–11. doi: org/10.33573/ujoh2005.01.003. [in Ukrainian]
- Melnuk OG, Borovyk IG, Riabokon AI, Diuldieva TA, Morgun TM. Profesiyna zakhvoriuvanist pratsyvnnykh mashynobuduvannia Kharkivskoho regionu v 2012–2016 rokakh. Medychni perspektyvy. 2018; 23, 3(1): 142–147. doi: org/10.26641/2307-0404.2018.3(part1).142355. [in Ukrainian]
- Radchenko OM, Fedyk OV, Huta RR. Hematolohichni indeksy u khvorykh na khronichne obstruktyvne zakhvoriuvannya legen z anemiyeyu. Visnyk Ukrainskoyi medychnoyi stomatolohichnoyi akademiyi. 2019; 19, 3(63): 71–74. doi: 10.31718/2077-1096.19.3.71. [in Ukrainian]
- Rubtsov RB. Znachymist deiakykh zmin pokaznykh zapalennia u pratsyvnnykh hirnichorudnoyi ta metalurhiynoyi promuslovosti, hvorykh na pnevmokonioz u poiednanni z khronichnym obstruktyvnum zakhvoriuvanniam legen. Ukrainskyi zhurnal z problem medytsunu pratsi. 2018; 4(57): 40–47. doi: 10.29254/2077-4214-2020-3-157-137-141. [in Ukrainian]
- Sposib vyznachenia pronyknosti i perekysnoho hemolizu v odniy probi krovi: pat. 20618 Ukrayina. № A 2005 12718; zaiavl. 28.12.2005 ; opubl. 15.02.2007 ; Biul. № 2. 6 s. [in Ukrainian]
- Cullinan P, Muñoz X, Suojalehto H, Agius R, Jindal S, Sigsgaard T, et al. Occupational lung diseases: From old and novel exposures to effective preventive strategies. Lancet Respir Med. 2017; 5(5): 445–455. doi: 10.1016/S2213-2600(16)30424-6.
- De Matteis S, Heederik D, Burdorf A, Colosio C, Cullinan P, Paul K. Current and new challenges in occupational lung diseases. European Respiratory Review. 2017; 26: 170080. doi: 10.1183/16000617.0080-2017.
- Eteng MU, Ukpanukpong RU, Otu DO, Ajanaku VA. Dust on haematological parameters in adult Wistar rats. World Journal of Pharmaceutical Research. 2018; 7, 19: 180–187. doi: 10.20959/wjpr201819-13718.
- Farheen A, Hazari MAH, Khatoon F, Sultana F, Qudsiya SM. Hematological parameters are acutely effected by cement dust exposure in construction workers. Annals of Medical Physiology. 2017; 1(1): 31–35. doi: 10.23921/amp.2017v1i1.263312.
- Hillas G, Perlikos F, Tsiligianni I, Tzanakis N. Managing comorbidities in COPD. Int J Chron Obstruct Pulmon Dis. 2015; 10: 95–109. doi: 10.2147/COPD.S54473.
- Westberg H, Hedbrant A, Persson A, Bryngelsson I–L, Johansson A, Ericsson A et al. Inflammatory and coagulatory markers and exposure to different size fractions of particle mass, number and surface area air concentrations in Swedish iron foundries, in particular respirable quartz. Int Arch Occup Environ Health. 2019; 92 (8): 1087–1098. doi: org/10.1007/s00420-019-01446-z.

Стаття надійшла 14.04.2020 р.