ROLE OF VARIOUS PHAGOCYTIC CELLS IN REMOVAL OF QUARTZ DUST FROM THE LUNGS

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The total number of polymorphs, and also the number of polymorphs phagocytosing dust particles in perfusion fluid obtained from the alveoli and respiratory tract of rats made to inhale quartz dust for 4 or 8 months were much higher than the corresponding numbers of macrophages. The opposite relationship which, judging from data in the literature, is typical of inert and radioactive dusts, was found in perfusion fluid from lungs of the control rats, in which only ordinary atmospheric dust could be deposited. Polymorphonuclear phagocytosis is thus an important supplementary mechanism of self-cleansing from dust carrying with it the risk of silicosis. However, judging from the large number of particles present on the average per cell, macrophages play the dominant role in this case also.

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Phagocytosis is invariably found in the development of pneumoconiosis. It plays an essential role in the formation of the silicotic nodule, and death of a continuous series of cells caused by phagocytosis of silica particles is the primary factor leading to the development of the silicotic reaction. The special fibrogenicity of silica dusts is associated with their specific ability to damage macrophages [1]. At the same time, phagocytosis of dust deposited primarily in the alveoli is a vital link in self-cleansing of the alveoli. Results obtained by many investigators indicate that the phagocytic mechanism of alveolar self-cleansing is entirely dependent on macrophages [2, 3, 8]. However, it was shown 15 years ago by phage-contrast microscopy and by microfilming in vitro that this conclusion is valid only for certain so-called inert dusts (coal, aluminum, iron), while quartz particles are ingested more actively by macrophages than these "inert" materials, and at the same time, they are the only dust particles which are also phagocytosed by polymorphs [6].

The role of these various cells in phagocytosis of quartz dust was studied in the investigation described below.

EXPERIMENTAL METHOD

The technique of LaBelle and Brieger [7] as modified by Komovnikov [2] was used to study alveolar phagocytosis of dust particles in rats exposed to chronic inhalation of crushed quartz dust. Dust inhalation took place on alternate days, for 5-6 h per diem, the dust concentration in the chamber being 55 mg/m^3. Alveolar phagocytosis was studied in animals inhaling dust for 4 months, when, judging by the hydroxyproline content in the lungs, fibrosis was just beginning to develop, and at the end of the 8th month of inhalation, when fibrosis had attained a considerable degree.

The principle of the method is based on obtaining washings from the respiratory passages by extraction of the lungs from the body and counting the number of cells in an aliquot sample of perfusion fluid, then converting the result for the respiratory organs as a whole. Washings were obtained 24 h after the end of the last exposure to dust, i.e., at a time when accumulation of alveolar macrophages in the lungs had reached a maximum [2, 4, 7]. The cells were counted in a Fuchs-Rosenthal chamber, and films obtained by centrifugation of the lung perfusion fluid were then prepared, fixed with methanol or in formalin vapor, and stained by the Romanovsky – Giemsa method. After microscopic examination, the relative percentages

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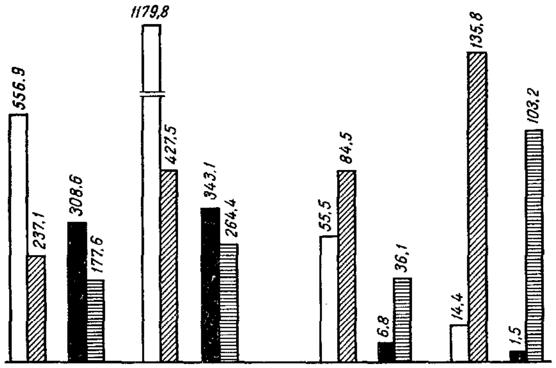

Fig. 1. Number (×10^4) of different cells in perfusion fluid from lungs of experimental (A) and control (B) rats after various times. Unshaded columns denote total number of polymorphs; black columns denote number of polymorphs with phagocytosed dust; obliquely shaded columns show total number of macrophages; horizontally shaded columns give number of macrophages with phagocytosed dust.

of macrophages, polymorphs, and other cells were determined. From this ratio and the total number of cells in the perfusion fluid, the absolute number of free pulmonary macrophages and polymorphs was calculated. Macrophages and polymorphs containing phagocytosed dust were counted separately, and the number of visible dust particles in each cell was determined. Alveolar phagocytosis was studied at the first time mentioned above in 18 experimental and 5 control rats, and at the second time in 14 and 5 animals, respectively.

EXPERIMENTAL RESULTS

Absolute numbers of macrophages and polymorphs and also of accompanying cells with phagocytosed dust particles in the experimental and control animals are illustrated in Fig. 1. In the control animals* phagocytosis by macrophages was much more marked at both times. These animals inhaled dust only from the surrounding air, in which there were no grounds for assuming the presence of any large amounts of quartz dust. Conversely, in rats specially exposed to inhalation of quartz, the number of free neutrophils in the lungs, including neutrophils containing phagocytosed dust, was greater than the number of macrophages (and, correspondingly, of macrophages with dust) at the same time.

Whereas the number of dust particles per polymorph did not exceed 2-3, the mean number of dust particles per macrophage after 4 months was 2.9 in the rats of the control group and 5 in those of the experimental group, and it eventually reached a maximum of 29-30.

It can therefore be postulated that the macrophage mechanism of self-cleansing is more effective than the polymorph mechanism in the case of inhalation of quartz dust, despite the smaller number of cells concerned. Nevertheless, the results indicate that, besides macrophages, polymorphs also play an essential role in this self-cleansing of the lungs from quartz, whereas elimination of "inert" and of radioactive dusts [2] takes place almost entirely through macrophages. This can evidently be regarded as an additional mechanism to protect the body against a specially aggressive, harmful factor.

These results are considered to be of particular importance because they were obtained from the first investigation of alveolar phagocytosis under the conditions of chronic inhalation of dust. Meanwhile, analysis of experimental results obtained by Ferin and co-workers [5], who investigated alveolar phagocytosis in rats sacrificed 25 days after a single exposure of 6 h to inhalation of dust present in the chamber in high concentration, shows that monocytes accounted for only 18% of the total number of phagocytic cells. These workers do not examine the role of polymorphonuclear phagocytosis, and like other investigators, Ferin [4], in his monograph on pulmonary clearance considers it to be purely a function of macrophages; nevertheless the results they describe are not in conflict with those of the present experiments.

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*Because of the very different absolute numbers of cells in perfusion fluid from the lungs of rats from the experimental and control groups, the values shown on the diagram for the different groups are on different scales.

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