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Research Article

Cytomorphological Changes of the Lungs Under the Influence of Electric Current of Low Frequency in the Experiment

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Abstract

During chronic suppurative lung inflammation (CSLI) cytological changes in lung tissue were manifested by a lymphoid reaction with the appearance of young plasma cells proceeding against a background of decreased macrophage activity, and morphological changes were characteristic of bronchopneumonia. After exposure to a short course of stimulating currents of low frequency, an increase in the number of macrophages and connective tissue in the partitions, thickening of the walls of the arterioles due to hypertrophy of the muscular membrane and an increase in the number of connective tissue were observed.

Keywords: *Chronic; Inflammation; Lungs; Experiment; Cytology; Morphology; Laboratory Animals; Electric Currents*

Introduction

Respiratory diseases currently take the 4th place in the structure of the main causes of population mortality, and their "contribution" to the reduction of working capacity and disability of the population is even more significant [1,3,4]. The medical and socio-economic importance of chronic inflammation in the bronchi and lungs, including pneumonia, is extremely high due to its prevalence in the structure of human morbidity, the increase in the development of Chronic Obstructive Lung Disease and the occurrence of SARS, significant mortality and disability of patients [4,10,12]. The severity and nature of the inflammatory reaction in the lungs, the development of regenerative processes depend on the degree of functional activity of inflammatory effector cells and their functional reserves [5,6]. Particular attention is paid to the disruption of the macrophage phagocytic activity, the development of secondary immunodeficiency of varying severity against the background of the region's environmental disadvantage [5,7,8,11], and the presence of bad habits. This leads to a restriction of the air flow associated with an enhanced pathological inflammatory response of the respiratory tract to the effects of damaging particles or gases [7,8,9]. Suppurative inflammation of the lung tissue proceeds for a long time, inflammatory infiltration resolves slowly, often accompanied by the development of focal pneumosclerosis and the formation of chronic pneumonia with the development of respiratory failure amid developed fatigue of respiratory muscles [3,6,10].

Objective of the Study

Carry out cytological and morphological studies of lung tissue in order to study the patterns of proliferative and destructive processes in experimental rats with a model of chronic suppurative pneumonia (CSP) in the dynamics of the stimulating effect of low-frequency electric current.

Materials and Methods

The main group consisted of 24 and healthy group consisted of 5 outbred white male rats weighing 150 - 200g. Animals were kept in the usual laboratory mode in vivarium conditions. The experimental model of CSP was reproduced according to the method of Batyrova Z.B., Shamirzaev N. Kh [2]. A cytological study of preparations of fingerprints of lung tissue colored according to Gimsa-Romanovsky was carried out according to S.T. Nadzhimitdinov [9]. For morphological studies, pieces of lung tissue taken after slaughter were fixed in a 10% solution of neutral formalin. Paraffin histological sections 5 - 6 μm thick were stained with hematoxylin eosin. Microscopy of the preparation was carried out under an XS-213 light-optical microscope and a Leica microscope.

On the 45th day from the start of the experiment, the rats with evoked CSP model were treated with the stimulating effect of a low-frequency electric current.

In the first group, the Stimul-1 apparatus was used. Current strength 0.1 mA, frequency 2.5 - 5.0 ms. Exposure time is 5 min. e/d. The course is 7 days.

In the second group of CSP, current was supplied from the "e-Shifo" program embedded in the smartphone. The current was supplied with a frequency of F-50Hz, a modulation depth of -W-100 and a power of -V-10v. for 5 minutes, e/d, No. 8.

In the third group of CSP, current was supplied from the "e-Shifo" program embedded in the smartphone. The current was supplied with a frequency of F-40 Hz, a modulation depth of -W-50 and a power of -V-10v. for 5 minutes, e/d, No. 8.

The control group consisted of 6 rats with CSP (no treatment). On the pre-treated surface of the skin of rats with CSP, electrodes 1.5 × 1.3 cm in size were fixed bilaterally along the mid-axillary line at the level of 7 - 8 ribs.

Research Results and Discussion

Macroscopic picture on the 45th day of the CSP model: non-apneumatic lungs, in some areas - pale gray-red or dark red, the test of a visible consistency, small hemorrhages are often found under the pleura and parenchyma, and pulmonary edema, hyperemia and foci were also observed suppuration against a background of tuberosity of the lung. In the section, a foamy, unclean liquid, sometimes colored pink, flows from the gaps of the bronchi. A purulent, thick, greenish-colored liquid was released in the section of the suppuration site.

In healthy rats without signs of inflammation in the cytological picture, according to the data of imprints from lung tissue, the cellular elements of tissue and blood origin were as if in a dispersed state. Pulmonary alveoli were smooth, empty, pulmonary macrophages were inactive with unexpressed digestive vacuoles. They were located far from the alveoli, amounting to 3.4 ± 1.8% in the first row, 12.7 ± 2.9% in the second row, and far from the alveoli in the third row, i.e. 63.5 ± 5,8% in lung tissue. Lymphocytes accounted for 11.1 ± 4.7%. Neutrophilic white blood cells accounted for 2.1 ± 0.3% (Figure 1).

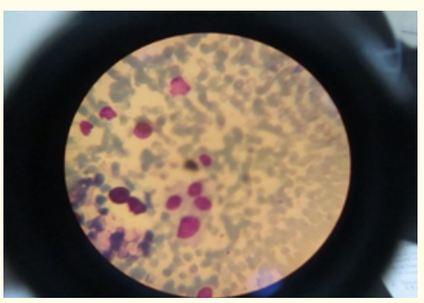

Figure 1: *Control-healthy lung Magnification 100, immersion IMG_0320.jpg.*

In CSP on fingerprint preparations, pulmonary macrophages with unexpressed digestive vacuoles had different sizes and collocation relative to the alveolar membranes. Macrophages were located mainly adjacent to the alveoli (the first level 15.4 ± 4.6%, in the lung tissue in the second row from the alveoli 12.3 ± 1.9% and the third level away from the alveoli 9.7 ± 8.4%) Some macrophages were located in the center of the alveoli. The presence of single plasma cells of neutrophils, epithelial cells against the background of an abundance of lymphocytes (31.9 ± 3.7%) was revealed (Figure 2).

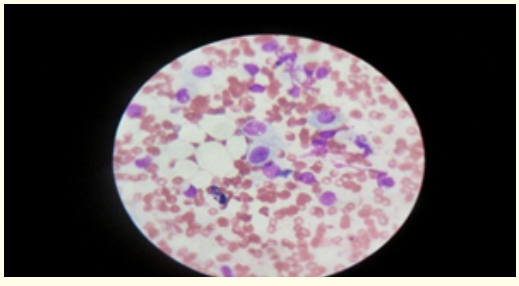

Figure 2: *CSP. Macrophages and lymphocytes. Magnification 100 immersion IMG_0320.jpg.*

In a healthy area around the alveoli and in lung tissue, an abundance of lymphocytes, neutrophilic leukocytes, with unexpressed digestive vacuoles of macrophages located in 1 - 2 rows from the alveoli was observed. Pulmonary macrophages had different sizes and collocations relative to the alveolar membranes (Figure 2). In the pathological purulent area, an abundance of destroyed neutrophilic white blood cells up to 100%, young single destroyed lymphocytes and single tetraploid cells were revealed (Figure 3).

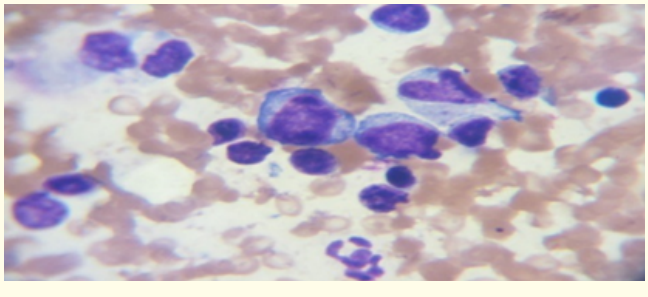

Figure 3: *CSP pathological purulent area of the lung. Magnification 100 imersion.jpg.*

A microscopic picture of the morphology of the lung tissue of healthy rats: airy, with the walls of the alveoli spread and a clear differentiation of the walls of the bronchioles against the background of the surrounding tissue. The walls of the alveoli are represented by thin septa, which, even normally in rats, are infiltrated by single, sometimes more pronounced, clusters of histiolymphocytic elements, which, apparently, is a protective factor. Hyperplasia of the lung's own lymphoid tissue is also characteristic.

In the lung tissue in experimental animals, in contrast to the control group, the inflammatory and destructive processes of the lung tissue, which can be traced both in the walls of the bronchioles and in the surrounding bronchial tissue, come to the fore. So, on serial sections of lung tissue, manifestations of inflammatory changes prevailed. These manifestations were characterized by capillary and arterial congestion, focal lymphohistiocytic macrophage infiltration of the alveolar septa, and moderately pronounced interstitial edema. The alveolar epithelium in the preserved air sections of the lung tissue adheres tightly to the walls of the interalveolar septa. Circulatory disturbances with erythrodiapedesis to the lumens of the alveoli and bronchioles prevailed. These changes were diffuse or focal in nature.

The arterial and capillary plethora of the septum vessels is clearly expressed. The interalveolar septa are significantly thickened due to sclerosis, edema, and cell infiltration, which in the vast fields of the lung tissue leads to a decrease in the ventilation of the alveoli, their subsidence and atelectasis in some, and the appearance of emphysematously enlarged areas in other parts of the pulmonary parenchyma. In the lumens of most bronchioles, mucus plugs are determined, homogeneously eosinophilically stained, which further exacerbates the processes of impaired pulmonary ventilation. Part of the animals showed diapedetic hemorrhages in the septum. In the lumens of the alveoli, single, desquamated alveolocytes are found.

Morphological changes in lung tissue in CSP on day 45 from the start of the experiment are shown in figure 4.

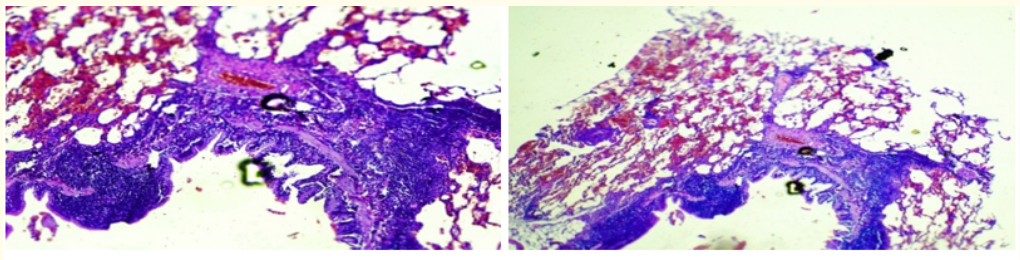

Figure 4: *Rat lung with CSP. Destructive and inflammatory changes in the lung tissue. In the gaps of the bronchioles, mucopurulent plugs. Increased. 10 * 10.*

After treatment, the results of cytological changes in lung tissue in CSP are presented in figure 5 and 6.

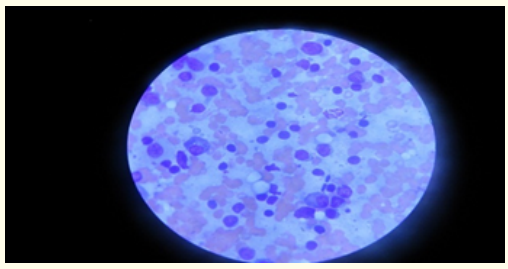

Figure 5: *CSP-lungs. After treatment, "Stimulus-1" (group 1). Magnification 100 imersion.jpg.*

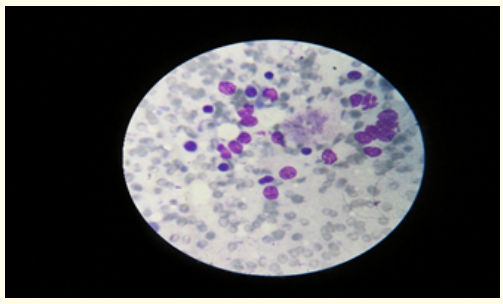

Figure 6: *After treatment from the e-Shifo program embedded in the smartphone (group 2 - 3). Magnification 100 imersion.jpg.*

In the first group of rats, an abundance of lymphocytes of 48% ± 3.4% was observed in the lung tissue, and single macrophages with indolent digestive vacuoles had different sizes and collocations relative to the alveolar membranes. Macrophages located close to the alveolus accounted for 38.0 ± 5.8%.

In the second and third group after treatment, the cytological picture of lung tissue corresponded to the data of the first group. In a healthy area of the lung, an abundance of lymphocytes was observed (46.0 ± 6.2%). Macrophages with indolent digestive vacuoles were located in the first and second row relative to the alveolar membranes (43.0 ± 1.9%).

In the pathologically purulent foci of lung tissue after exposure to the prescribed course of procedures, an abundance of neutrophilic leukocytes (59.9 ± 4.9%), macrophages of little activity without digestive vacuoles randomly located in the tissue of the purulent foci (32.8 ± 5.6%) was observed. With prolonged chronic purulent pneumonia, even against the background of treatment procedures, a torpid course of the inflammatory process occurred, and for a long time there was the presence of alveolar macrophages in the alveolar membranes and a neutrophilic-leukocyte-lymphoid reaction around them (Figure 7).

Morphological changes in the lungs after treatment in the experimental groups of rats were manifested in the form of an increase in the number of connective tissue in the partitions, an increase in the number of macrophages, thickening of the walls of arterioles due to hypertrophy of the muscular membrane and an increase in the amount of connective tissue.

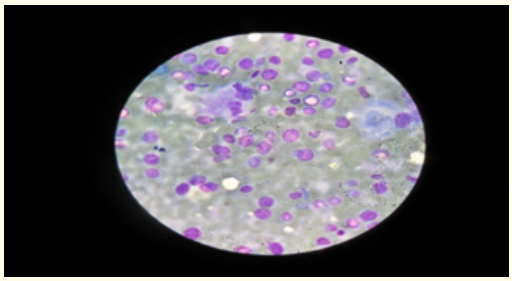

Figure 7: *CSP. Pathological purulent area of the lung after treatment (1 - 3 groups). Magnification 100 imersion.jpg.*

So, in rats of the first group, a focal marked inflammatory polymorphic cell infiltration and edema of the septa with focal atelectasis, venous congestion, focal changes: erythrodiapapeesis in the tissue remained; emphysema; distelectases and slight proliferation of peribronchial lymphoid tissue. There was also an accumulation of dense organized masses in the gaps of some alveoli.

In the second group of rats treated according to the "e-Shifo" program, plethora, focal extensive hemorrhages in the septa, and alveolar lumens were determined. Against the background of severe hyperplasia of lymphoid tissue, mild inflammatory infiltration was determined, but there were hemorrhages, focal emphysema.

Moderate round-cell infiltration of diffuse septa persisted, there were practically no signs of hyperplasia of peribronchial lymphoid tissue.

In the third group of rats, unexpressed hyperplasia of peribronchial lymphoid tissue, thickening of the walls of the arterioles, focal emphysema was observed, however, there was a sharp decrease in inflammatory infiltration, but there were focal hemorrhages.

In the control group of rats without treatment, there was diffuse infiltration of the interalveolar septa, lymphoid tissue was completely absent, obvious hypertrophy, distelectases, focal emphysema, edema of the septa, uneven spasm of the walls of the bronchioles in the walls of the arterioles.

Conclusion

The main feature of cytological changes in animals with CSP is the lymphoid reaction, which proceeds against the background of a decrease in macrophage activity, indicating a decrease in the body's protective capabilities in the chronic purulent process in the lung tissue in CSP. Stimulating low-frequency currents from the Stimul-1 apparatus and from the e-Shifo program embedded in a smartphone revealed the same type of changes, which are characterized by a tendency to decrease the inflammatory response in lung tissue, especially in experimental rats with an indolent inflammatory process.

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