MORPHOLOGY AND PATHOMORPHOLOGY

Pathomorphological Peculiarities of Microcirculatory Bed in Bronchial Wall in Workers Employed in Mining and Chemical Industry

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Morphological alterations of microvessels in bronchial mucosa and blood capillaries of alveolar septa during endobronchitis were examined in workers employed at a plutonium plant and not employed residents (Zheleznogorsk, Krasnoyarsk Region). Alterative, destructive, and dysadaptive changes in pulmonary vessels of workers were paralleled by developing reparative and adaptive processes in neighboring capillaries.

Key Words: *bronchial and transbronchial biopsy; blood capillaries; workers of mining and chemical plant; light and electron microscopy*

Rapid development of atomic technologies, tests of nuclear weaponry, and postaccident contamination of territories with artificial radionuclides require comprehensive evaluation of the effects of ionizing radiation on humans [2]. The respiratory system is frequently affected by aerosol and penetrating radiation [9-11]. Various cell populations actively participate in the formation of a peculiar nosomorphosis [2,8,12,13]. A special role in this process is played by microcirculatory bed (MCB) of the bronchial wall and respiratory tract [5-7]. A wide spectrum of morphological alterations in all MCB elements observed in liquidators of Chernobyl accident prompted us to study fine mechanisms of damage to blood vessels in workers employed at Zheleznogorsk mining and chemical plant (MCP, Krasnoyarsk Region) producing plutonium like in Mayak MCP in Chelyabinsk Region. Previously we studied histological and ultrastructural alterations in cell populations of bronchial epithelium in bronchial and transbronchial bioptates obtained from MCP workers [1].

We carried out light and electron microscopic examination of MCB vessels in bronchial and transbronchial bioptates from MCP workers and town residents not employed at MCP.

MATERIALS AND METHODS

Bronchial (n=21) and transbronchial (n=5) bioptates from MCP workers (males aged 41-45 years, mean age 46.7±7.6 years) with chronic obstructive bronchitis were examined by light and electron microscopy. Bronchial bioptates from male patients (age 48-55 years, mean age 50.2±4.4 years, n=9) lived in Zheleznogorsk but not employed at MCP served as the control. Duration of service at MCP was 15.4±2.8 years, and history of the disease was 10.1±2.1 and 11.1±1.9 years in MCP workers and residents, respectively. All patients were tobacco smokers with smoking history of 18.0±2.5 years. In these groups,

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the smoking history and disease history did not significantly differ.

For morphological study, paraffin sections were stained with hematoxylin and eosin or picrofuchsin and fuchseline; in addition, periodic acid-Schiff reaction was performed. For electron microscopy, the specimens were fixed in 2.5% glutaraldehyde on 0.1 M phosphate buffer (pH 7.4), postfixed in 1% OsO_4, and embedded in Epon-Araldite. Ultrathin sections were contrasted according to Reynolds and examined under a JEM-100C transmission electron microscope. Semithin sections were stained with methylene blue and azure II basic fuchsin.

RESULTS

Examination of semithin sections showed that bronchial mucosa lamina propria (BMLP) of MCP workers was enriched with microvessels with predominance of blood capillaries. Some vessels had widened lumens with elongated and flattened endotheliocytes and were characterized by marginal platelet stasis. Collapsed vessels and vessels with thickened, deformed, and sclerotic walls and hyalinosis foci were also seen (Fig. 1, *a-d*).

In transbronchial bioptates of MCP workers, blood capillaries, arterioles, and venules had elongated shape. Endothelium was either markedly thinned or thickened (Fig. 1, *e, f*).

Deformation of microvessel walls and thickening of the basal membranes were seen in sites of squamous metaplasia of the bronchial epithelium. In deep layers of BMLP, arteriolar walls were markedly thickened, deformed, and sclerosed. Arterioles contained platelet ghosts and homogenous substances adherent to the intima, which was considered as endovasculitis with signs of organization (Fig. 1, *g*, *h*). On the whole, changes of BMLP microvessels were polymorphic. However, in sites of squamous metaplasia, vascular reactions were characterized by pronounced deformation, thickening of vascular walls, disintegration of the endothelium, and platelet adhesion to damaged endotheliocytes.

Electron microscopy revealed pronounced alterations in all components of microvessels in the bronchial and transbronchial bioptates from MCP workers. Endotheliocytes, pericytes, and basal membrane were more often affected than the subendothelial zone and pericapillary space.

The most common changes were formation of numerous cytoplasmic processes in endotheliocytes and impairment of their contacts. In fact, the connections between endotheliocytes were predominantly maintained by the cytoplasmic processes (Fig. 2, *a*). Another salient feature of endotheliocytes was alternation of light and dark cells. Light cells looked swollen and had clarified hyalo- and nucleoplasm and predominantly destructed organelles. By contrast, dark endotheliocytes are enriched with organelles, projected into the capillary lumen; and had active nuclei and numerous mono- and polysomes and a low number of pinocytotic vesicles (Fig. 2, *b*). Some capillaries contained fibrin filaments. Microclasmatosis and clasmatosis in endotheliocytes were often paralleled by thinning and sometimes disruption of the basal and lumenal plasmalemma (Fig. 2, *c*), destruction of mitochondria and granular endoplasmic reticulum, and reduction of Golgi complex. The nuclei in such endotheliocytes had signs of alterations, perinuclear space was markedly widened and contained fragments of other organelles (Fig. 2, *d*). In some blood capillaries, in particular in sites of dark-light cell alternation, we observed endotheliocytes with cytoplasm of medium electron density. These endotheliocytes contained young mitochondria, while the number of altered mitochondria in these was sharply decreased.

In transbronchial bioptates we observed blood capillaries with flattened endotheliocytes connected via fenestrae and characterized by considerably vacuolated cytoplasm. These capillaries had wide subendothelial zone, loosened basal membrane, and vast precapillary space with hyperplastic collagen fibrils between the basal membrane and alveolar septum (Fig. 2, *e*). Platelets were seen both in capillary lumens and pericapillary space (Fig. 2, *f*) and were in close contacts with luminal surface of endotheliocytes. We consider all these alterations as the signs of microthrombosis.

Our findings and published data [4-6] attest to structural rearrangements in MCB during chronic bronchitis. The morphological changes found on semithin sections and ultrastructural analysis revealed the common changes in blood capillaries of MCP workers. However, we also revealed some peculiarities in the structure and ultrastructure of microvessels, which depended on the severity of the pathological process. These alterations resulted from endothelial imbalance caused by pronounced changes in the epithelial layer and BMLP structures. The presence of dark functionally active endotheliocytes with newly formed organelles and hyperplasia of collagen fibers attest to reparative processes targeted to MCB as the major component of trophism and metabolism of the bronchial tree and respiratory tract. Structural variability and submicroscopic peculiarities of blood capillaries and pathological changes in the entire vascular wall including endotheliocytes, subendothelial zone, basal membrane, and pericapillary space combined with disorientation and hyperplasia of collagen fibrils attest to subcompensation and in some cases decompensation in MCB vessels [5,6]. These changes probably result from long-term effects of aerogenic radionuclides and

incorporated radioactive particles. Considerable changes in blood capillaries, arterioles, and venules with pronouncedly deformed and thickened basal membrane, and the platelets and microclamatotic substances in the lumens were found in sites of metaplasia in the bronchial epithelium.

Electron microscopy and examination of semithin sections prepared from bronchial and transbronchial bioptates revealed pronounced alterations in MCB of MCP workers, and the severity of these alterations did not strictly correlate with the degree of damage to the bronchial epithelium. Morphological changes in the

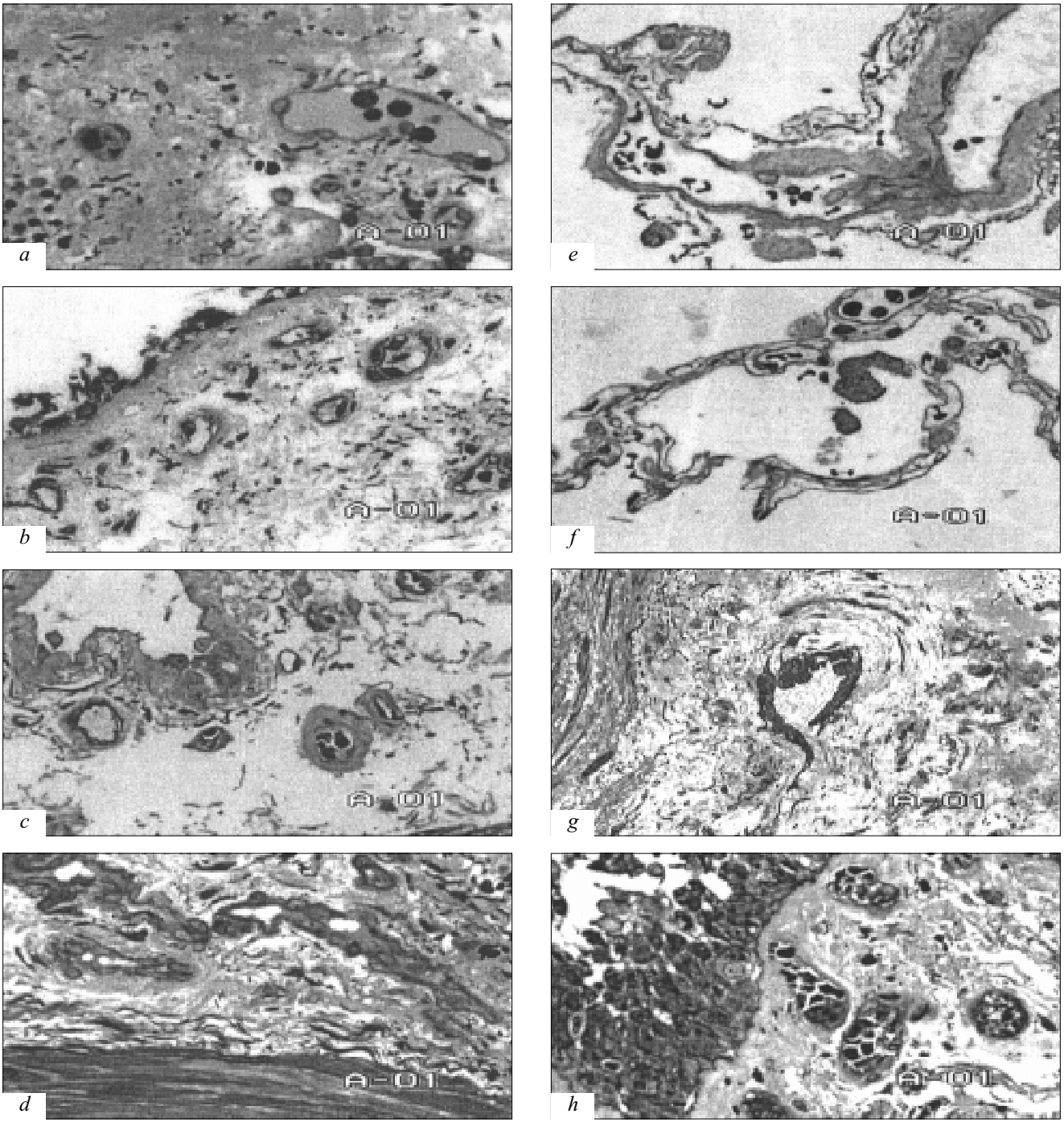

Fig. 1. Light microscopy of semithin sections of bronchial (*a-d*) and transbronchial (*e-h*) bioptates of lamina propria of bronchial mucosa. Staining with methylene blue and azure-II basic fuchsin, ×250. Capillaries of different size and shape, collapsed vessels and vessels with thickened and deformed walls (*a-d*); and hyalinosis of vessel walls (*b, c*). Elongated blood capillaries, arterioles, and venules; thickened (*e*) or thinned (*f*) endothelium; deformation, thickening, and perivascular sclerosis of the arterial wall in deep layers of lamina propria (*g, h*); homogenous substance closely attached to vascular intima (*g*).

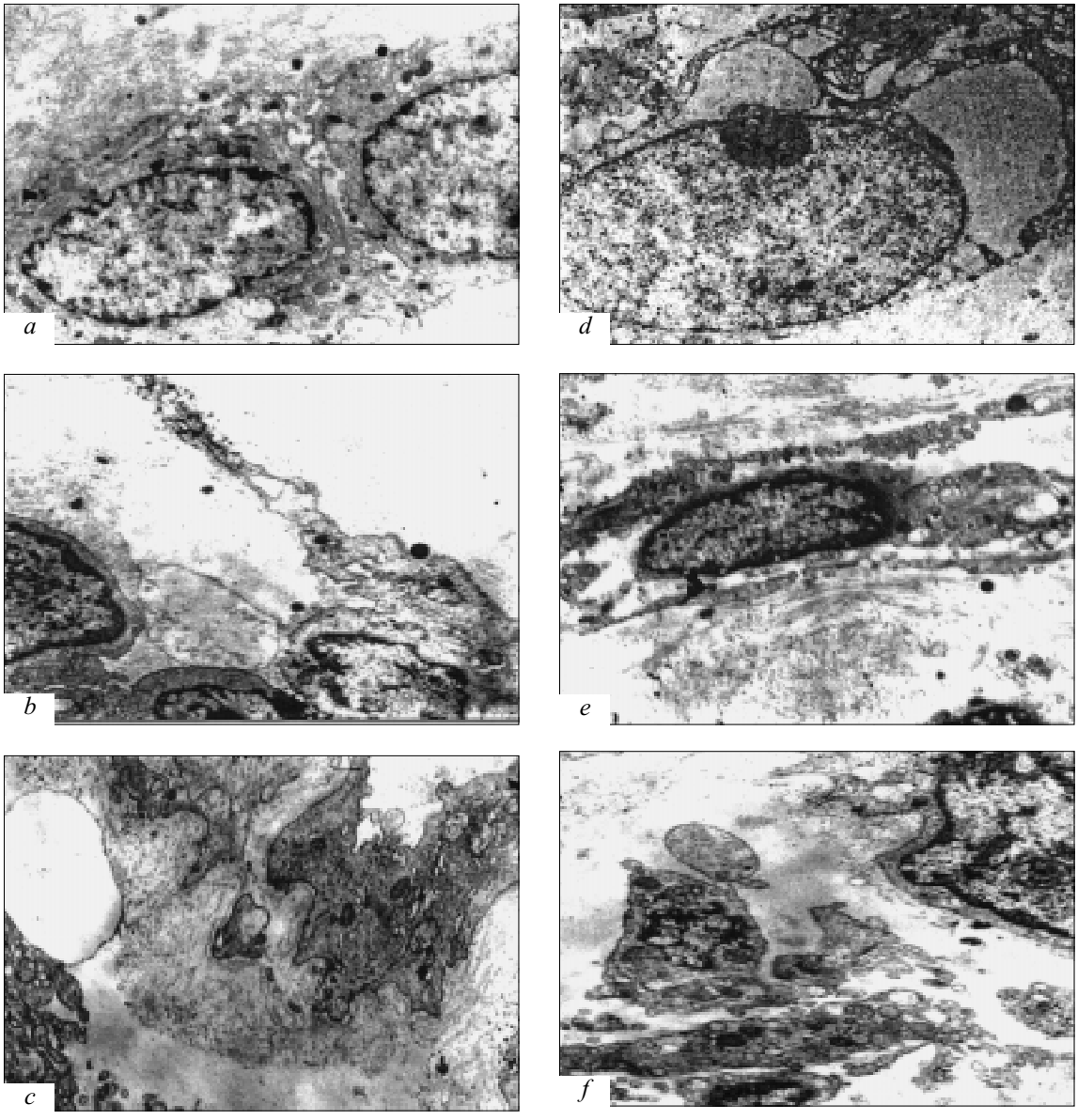

Fig. 2. Transmission electron microscopy of bronchial and transbronchial bioptates of bronchial mucosa lamina propria; ×10,000 (*a-c, e, f*) and ×12,000 (*d*). Endotheliocytes of blood capillaries, contacts between endotheliocytes via multiple cytoplasmic processes, widening and loosening of the basal membrane (*a*); light and dark endotheliocytes, clasmatosis, clusters of fibrin filaments in the capillary lumen (*b*); microclasmatosis and clasmatosis, widening and loosening of basal membrane with sites of plasmalemma intermittence (*c*); considerable widening of perinuclear space with sites of partial necrosis (*d*); pronounced vesiculation of cytoplasm in flattened endotheliocytes; fenestration; widening of subendothelial area and pericapillary space; and hyperplasia of collagen fibrils (*e*); platelets in pericapillary space, signs of microclasmatosis and clasmatosis (*f*).

vascular walls of MCB from BMLP and blood capillaries of alveolar septum were versatile; they affected all components of the vascular wall and induced predominantly the destructive and dysadaptive processes. The most characteristic features of these changes were microthrombi, thickening, deformation, and hyalinosis of arteriolar wall, clasmatosis and microclasmatosis, and intermittence of the luminal and basal endotheliocyte plasmalemma.

Thus, although changes in the epithelium of bronchial mucosa in MCP workers were minimal, considerable alterations were revealed in all components of their bronchial vascular bed. Changes in MCB of MCP workers (microthrombosis; thickening, deformation, and hyalinosis of arteriolar wall, clasmatosis and intermittence of luminal and basal endotheliocyte plasmalemma) were not detected in town residents not employed at MCP. Pronounced changes attesting to alteration, destruction, and degenerative processes in endotheliocyte plasma membranes and organelles were paralleled by reparative and adaptive processes in the neighboring capillaries.

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