MORPHOLOGIC AND ULTRASTRUCTURAL CHANGES IN THE LUNGS UNDER THE INFLUENCE OF SOME SHOCK-INDUCING FACTORS

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KEY WORDS: shock; lungs; edema.

The morbid anatomical characteristics of shock lung are contradictory because the patients die in the stage of pulmonary edema [2, 3, 6, 7, 10]. Morphological changes in the organs in shock are known to reflect the underlying disease and the response to shock-inducing and iatrogenic factors [4].

The aim of this investigation was to study the early structural changes in healthy lungs arising in the course of time under the influence of various shock-inducing factors during the first 72 h of exposure, and allowing for the state of the surfactant system.

EXPERIMENTAL METHOD

Three series of experiments were carried out on 234 guinea pigs (78 animals in each series). In series I measured trauma was inflicted on the anterior surface of the animal's chest [1]. In series II acute blood loss was induced by taking blood in one session from the left ventricle in a volume of 25% of the circulating blood volume. In series III the animals were given an intraperitoneal injection of 10 mg/kg of an extract of salmonella endotoxin lipopolysaccharide. Intact guinea pigs and guinea pigs receiving an intraperitoneal injection of sterile physiological saline (50 animals) served as the control. An extremal state and signs of respiratory failure were observed in the animals in all series of experiments: rapid respiration (up to 170-200 cycles/min), prostration, lateral position, cyanosis of the tongue, seizures, frothing at the mouth. Material was fixed in 10% neutral formalin solution, buffered by Lillie's method. Paraffin sections of the lung and liver were stained by Van Gieson's method and with hematoxylin and eosin. Parallel studies were made of semithin sections of the lung stained with methylene blue and basic fuchsine, and the results were compared with data of electron microscopy. One component of the surfactant system (the glycocalyx) was investigated by electron-histochemical methods, using ruthenium red [5] and fixing mixtures prepared after Luft [8], and also the physical method of Pattle [9].

EXPERIMENTAL RESULTS

In all series the initial changes recorded after 1 h were modification to the bronchioles, venules, and veins characteristic of spasm. Venules resembled arterioles in the thickness of their wall, and Kernohan's index was sharply increased. This was accompanied by the development of bilateral acinar contractile atalectases, alternating with foci of emphysema. At the ultrastructural level the basement membrane (BM) in areas of atalectasis was highly convoluted and edematous, and in the large alveolocytes, lamellar osmiophilic bodies (OB) escaped into the alveolar space (Fig. 1). Spasm of the venules together with open arterioles were accompanied by various disturbances of the microcirculation: sludging, leukostasis, concentration of many megakaryocytes in one field of vision, and syndrome of disseminated intravascular blood clotting (DIBC). Sludging, confirmed at the ultrastructural level, was characterized by dense agglutination of deformed erythrocytes. Leukostases were observed mainly in venules draining into veins contracted in spasm. In some preparations leukocytes were seen to have lost their specific lysosomal granules, so that electron-translucent areas appeared in the cytoplasm. The appearance of many megakaryocytes in capillaries of the alveolar septa was accompanied after 6 h by accumulation of platelets among the blood cells.

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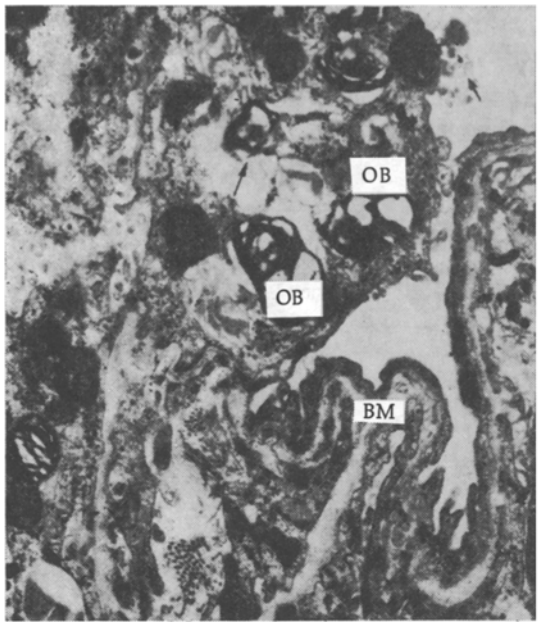

Fig. 1

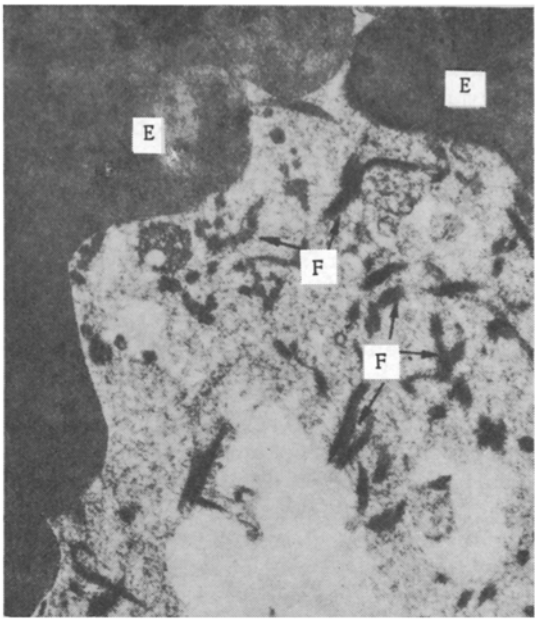

Fig. 2

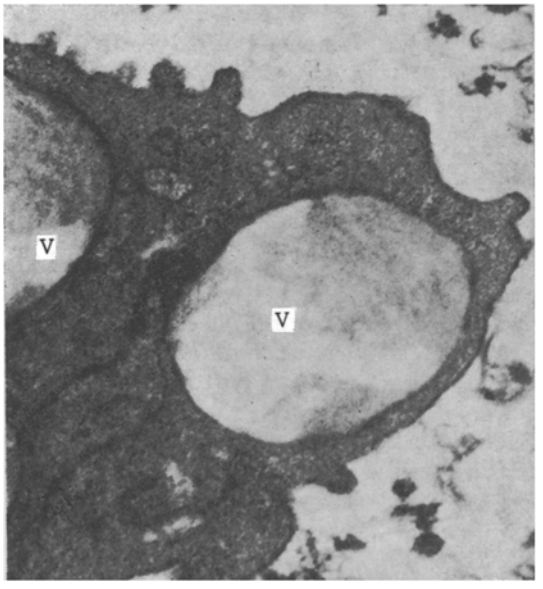

Fig. 3

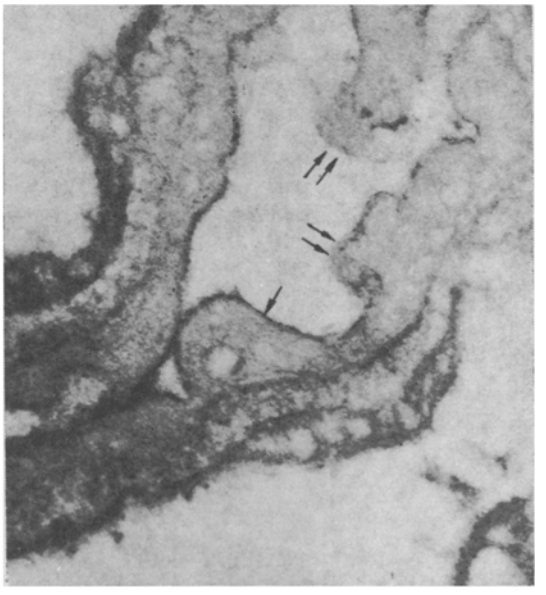

Fig. 4

Fig. 1. Large alveolocytes 6 h after trauma: release of lamellar osmiophilic bodies into alveolar space (arrow). 4000 ×.

Fig. 2. Capillary lumen 6 h after acute blood loss: clumps of fibrin (F) visible among deformed erythrocytes (E). 10,000 ×.

Fig. 3. Large alveolocyte 12 h after blood loss: large vacuoles (V) visible in cytoplasm. 14,000 ×.

Fig. 4. Disturbance of glycocalyx layer in areas of atelectasis 24 h after trauma: Glycocalyx is thinner (single arrow) or absent (double arrow). 32,000 ×.

Meanwhile clumps of fibrin were found among the blood cells, signifying the development of the DIBC syndrome (Fig. 2), which was particularly conspicuous in the period from 6 to 48 h in all series of experiments.

Disturbances of the microcirculation developed parallel with changes in the capillary endothelium. After only 1 h, especially in the series with salmonella endotoxin, large vacuoles and separation of the endothelium from the basement membrane could be seen. In addition, widening of the interendothelial junctions was observed, also with denudation of the basement membrane.

As regards the surfactant system, during the first 6 h increased discharge of lamellar bodies, destined for surfactant formation, by large alveolocytes was observed, but in spite of this, the stability index fell only a little to 0.71-0.68 (normal 0.84 ± 0.01). After 6 h, instead of the majority of typical lamellar bodies, large vacuoles (V), sometimes with lipid-like contents (Fig. 3), remained in the cytoplasm of the large alveolocytes.

Histochemical investigation with the aid of ruthenium red revealed local loosening of the structure of the glycocalyx during the first 6 h, with the formation of dense concentrations of glycosaminoglycans without disturbance of the integrity of the layer. The stability index during this period was not below 0.6. After 12 h the layer of glycosaminoglycans usually detached itself into the lumen of the alveoli in the form of electron-dense material and the surface layer lost its precise structure. The stability index fell at this time below the critical level, i.e., below 0.6; according to data in the literature [5] this is evidence of inactivation or absence of surfactant. After 24 h individual regions of the plasmalemma of the alveolar epithelium remained free from glycocalyx (Fig. 4). The stability index at this period reached its lowest level (0.48 ± 0.01). These changes are evidence that a surfactant-dependent factor was added to the contractile mechanism of atelectasis.

The changes described in the air—blood barrier led to the development of early interstitial edema, which during the first 6 h was already expressed at the ultrastructural level as disorganization and swelling of collagen and elastic fibers and the appearance of vacuoles containing edema fluid in the cytoplasm of the fibroblasts. Intra-alveolar edema was recorded at the ultrastructural level after 6-12 h and at the histological level after 24 h in all series.

Having discovered characteristic structural changes in the lungs, developing under the influence of the shock-inducing factors used, certain differences were nevertheless noted in the degree and time of their development in the different series. For instance, after injection of salmonella endotoxin changes in the lungs were characterized by particularly marked injury to the capillary endothelium, or even by its necrosis, as early as in the first 6 h of the experiment, so that diffuse edema, not limited to the zone of atelectasis, developed earlier than in the other series and extravasation of blood cells into the alveoli, where erythrophagocytosis by leukocytes was observed, was a more prominent feature. In acute blood loss the sludging syndrome was ill defined, for plasmatization and emptying of the capillaries occurred, so that the picture corresponded to one of the appearance of microprocesses of endothelium, partitioning off the capillaries. In trauma atelectases with hemorrhages and with fibrin threads predominated in the alveoli, and the DIBC syndrome was more clearly defined.

The results thus indicate that under the influence of shock-inducing factors changes of a unique kind develop in the healthy lungs and lie at the basis of respiratory insufficiency. They were observed in the present experiment in 83.3% of cases, whereas changes in the liver characteristic of shock (loss of the trabecular structure, ballooning of hepatocytes, and leukostases of the sinusoids) appeared in 100% of cases.

LITERATURE CITED

1. I. K. Esipova, G. V. Solntseva, G. G. Rogatskii, et al., Éksp. Khir., No. 5, 17 (1975).
2. I. K. Esipova, Arkh. Patol., No. 1, 66 (1980).
3. M. I. Lytkin, E. D. Kostin, A. L. Kostyuchenko, et al., Septic Shock [in Russian], Leningrad (1980).
4. N. K. Permyakov, in: Abstracts of Proceedings of the 7th All-Union Congress of Pathologists [in Russian], Tashkent (1983), pp. 352-355.
5. L. K. Romanova and A. K. Boikov, Byull. Éksp. Biol. Med., No. 2, 105 (1974).
6. M. A. Sapozhnikova and M. V. Barinova, Arkh. Patol., No. 10, 50 (1980).

7. L. Kádas and K. Szél1, Acta Morphol. Acad. Sci. Hung., 29, 395 (1981).
8. J. H. Luft, Anat. Rec., 171, 347 (1971).
9. R. E. Pattle, Physiol. Rev., 45, 48 (1965).
10. G. G. Pietra, J. R. Ruttner, W. Wust, et al., J. Trauma, 21, 454 (1981).

CORTICAL EFFERENTS OF DIFFERENT PARTS OF THE CAT ORBITOFRONTAL CORTEX

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As the result of a combined approach, several functional differences have been discovered in the frontal regions [2, 6]. The anterior zone of the frontal neocortex is known as the orbitofrontal cortex (OFC) [13, 14]. In the process of evolution there is a progressive increase in the complexity of the structure and functions of OFC, which is the precursor of the anterior zone of the human frontal cortex [5, 11], with its higher integrative functions.

In the cat the term OFC is taken to mean the proreal gyrus and the anterior part of the orbital gyrus, adjacent to the presylvian sulcus. Efferent connections of this cortex in the cat after destructuion of OFC in its entirety have been described in one or two publications [7]. There is no information in the literature on efferent connections of different parts of OFC, although such information could be important for our understanding of its structural-functional organization. In view of these considerations it was decided to undertake the present investigation.

EXPERIMENTAL METHOD

Experiments were carried out on 29 adult cats subjected to unilateral subpial extirpation of different parts of OFC under intraperitoneal pentobarbital anesthesia: the medial part (P_1), and superior (P_2) and inferior (P_3) zones of the dorsolateral part of the proreal gyrus (PfG) and the anterior zone of the orbital gyrus (G). The animals were killed 6-8 days later. The brain was fixed for 3-4 weeks in neutral formalin. Series of frontal brain sections were impregnated by Nauta's method and its modifications (Fink—Heimer and Kawamura—Niimi). The depth of injury to the cortex was verified in preparations stained by Nissl's method.

EXPERIMENTAL RESULTS

Destruction of the cortex of P_1 (part of area 8 on the medial surface of the hemisphere) was accompanied by the appearance of fragmented preterminals in the cortex of the posterior sigmoid gyrus (PSG) and the superior part of the coronal gyrus (CG, area 4) of both hemispheres in layers III-V, and of the anterior sigmoid gyrus (ASG, area 6) of the injured hemisphere. A moderate number of altered preterminals was observed in the cortex of the anterior suprasylvian gyrus (ASSG, area 5) in layers III-V of both hemispheres. Massive destruction of fibers was discovered in the cortex of the gyrus cingulus (GC, area 24), mainly ipsilaterally. Endings of axons from P_1 were identified also in the presubiculum (Ps), the entorhinal region (ErR), the piriform cortex (PiC) of the injured hemisphere, and in the cortex of the dorsolateral part of the proreal gyrus (area 8) of both hemispheres.

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