All these data show that elevation of the plasma β-ELIR level accompanies stress formation, including the development of a state of shock in baboons. A definite role in the regulation of the plasma β-endorphin level may be played by the paraventricular-perifornical region of the hypothalamus. Elevation of the β-endorphic level probably takes place on account of increased hydrolysis of β-lipotropin and also on account of its increased synthesis in the pituitary.

LITERATURE CITED

1. S. Amir, Z. W. Brown, and Z. Amit, Neurosci. Biobehav. Rev., 4, 77 (1980).
2. A. S. Foutz, C. Dauthier, and B. Kerdelhue, Brain Res., 263, 119 (1983).
3. S. Haber and R. Elde, Neuroscience, 7, 1049 (1982).
4. R. Henry, Neurosci. Biobehav. Rev., 6, 229 (1982).
5. D. T. Krieger, in: Endorphins '78, Budapest (1978), pp. 275-290.
6. R. Przewlocki, M. J. Millan, C. Gramsch, et al., Brain Res., 242, 107 (1982).
7. L. P. Renaud, in: Neuroactive Drugs in Endocrinology, Amsterdam (1980), pp. 49-67.
8. O. A. Smith, J. L. De Vito, and C. A. Astley, in: Changing Concepts of the Nervous System, New York (1982), pp. 569-584.
9. J. I. Szekely, in : Opioid Peptides. Vol. 3, Boca Raton, Fla (1983), pp. 69-106.

MECHANISM AND TIMES OF DEVELOPMENT OF HYALINE MEMBRANES IN ACUTE RESPIRATORY FAILURE DUE TO TRAUMA

UDC 616.24-008.64-036.11-02:617.542-001]-07:616.24-003.823

I. K. Esipova and S. P. Boikova

KEY WORDS: shock lung, microcirculation, hyaline membranes.

The question whether hyaline membranes (HM)of the lungs in adults with an acute respiratory failure syndrome are a feature of the disease itself or a complication developing during treatment remains unsolved. Some workers have observed the formation of HM in the shock lung syndrome only after artificial ventilation and transfusion of an inappropriate volume of fluid [8, 9, 12]. The problem of the times of development of HM, which is important for an understanding of the pathogenesis of respiratory failure, also is being discussed. Electron-microscopic investigations of the lungs of persons dying after chest injury, with the clinical picture of acute respiratory failure, revealed HM 1-7 days after death or later [5-7, 11, 12, 14].

In the investigation described below the possibility of HM formation in the absence of treatment was studied at the ultrastructural level on an experimental model of traumatic shock lung.

EXPERIMENTAL METHOD

A model of chest trauma accompanied by respiratory failure, and excluding any lesion of the vertebral column and spinal cord, was created in 78 guinea pigs weighing 300 g. The control consisted of 50 intact guinea pigs. The morphological investigations at the macroscopic, microscopic, and ultrastructual levels, were undertaken 1, 6, 12, 24, 48, and 72 h after trauma (13 animals at each time). Besides ordinary transmission microscopy, in order to study the lung surfactant, in 30 cases (five animals at each time) the animal was perfused with 3.6% glutaraldehyde in 0.1M cacodylate buffer (pH 7.3) through the pulmonary artery [15]. To detect glycosamino glycans of the surfactant and hypophase, ruthenium red was injected as a component of the fixing mixtures [2, 10].

EXPERIMENTAL RESULTS

In 100% of cases the clinical picture of respiratory failure was obtained. At the macroscopic and microscopic levels the typical picture of shock lung was discovered: a combination

Department of Pathological Morphology, Patrice Lumumba People's Friendship University.

Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 100, No. 12, pp. 679-682, December, 1985. Original article submitted May 20, 1985.

0007-4888/85/0012-1655$09.50

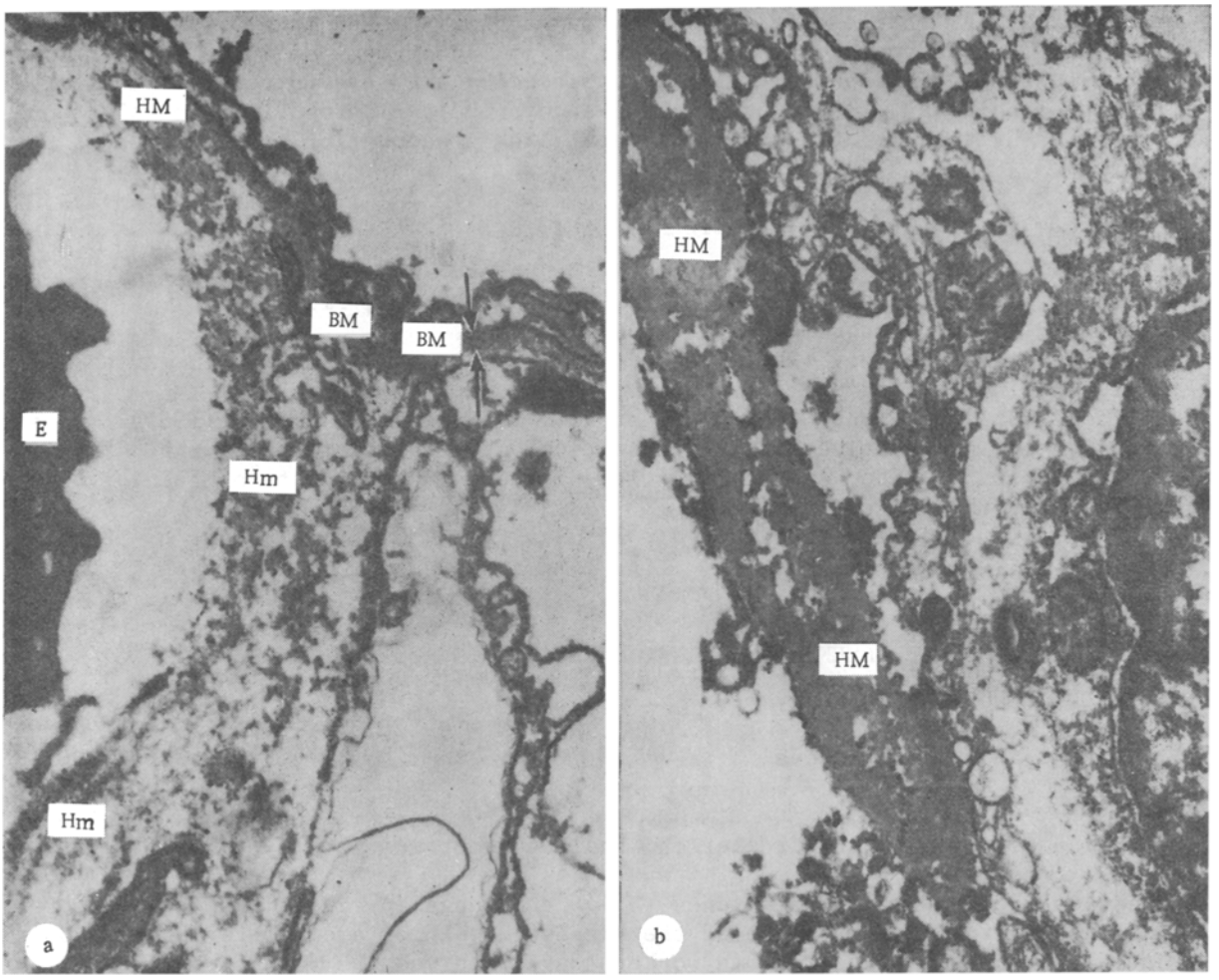

Fig. 1. Development of HM 72 h after trauma: a) HM consisting of granular and fibrillary deposits located directly on BM. BM is swollen, with indistinct borders. E) Erythrocyte; b) HM lies next to damaged cytoplasm of type I pneumocyte. Electron histochemistry. 14,000 x.

of widely spread bilateral foci of atalectasis, with disturbance of the microcirculation in the form of spasm of the venular bed of the lungs, accompanied by sludging and, in the overwhelming majority of cases, by a syndrome of disseminated intravascular blood (the DIBC syndrome) with focal hemorrhages and interstitial edema [1]. On histological investigation concentrations of homogeneous eosinophilic masses distinguished from intra-alveolar edema by their lamellar form, sharply demarcated inside the alveolus, and the more intensive eosinophilia were observed after 72 h in the region of the floor of the alveoli, in only five of 13 cases. At the ultrastructural level typical HM was observed also after 72 h. They had the appearance of granular or fibrillary deposits with fragments of cell organelles, lying next to the walls of the alveoli in the form of strips (Fig. 1). The type I pneumocytes lying beneath them became irregular in outline and multiple microprojections appeared on their free surface. The cytoplasm contained large vacuoles with edema fluid. The mitochondria appeared swollen with indistinct outlines. Detachment of the layer of type I pneumocytes from the basement membrane (BM) also was observed. The latter appeared swollen, felt-like, with indistinct boundaries, with electron-translucent zones over a wide area. In some places HM were in direct contact with the basement membrane modified as described above (Fig. 1a).

In the cytoplasm of the type II pneumocytes there were areas with floccular edema fluid, swollen mitochondria, and single osmiophilic lamellar bodies (OLB). The nuclear membrane in these cells was indistinct and blurred. Instead of typical OLB other pneumocytes contained large vacuoles. These changes in the alveolar epithelium are evidence of severe vacuolar degeneration of these cells. These disturbances in the pneumocytes were also observed before development of HM.

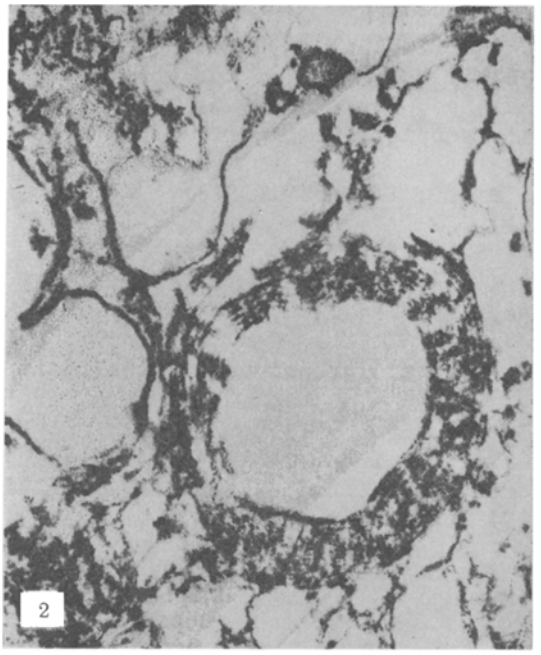

Fig. 2.

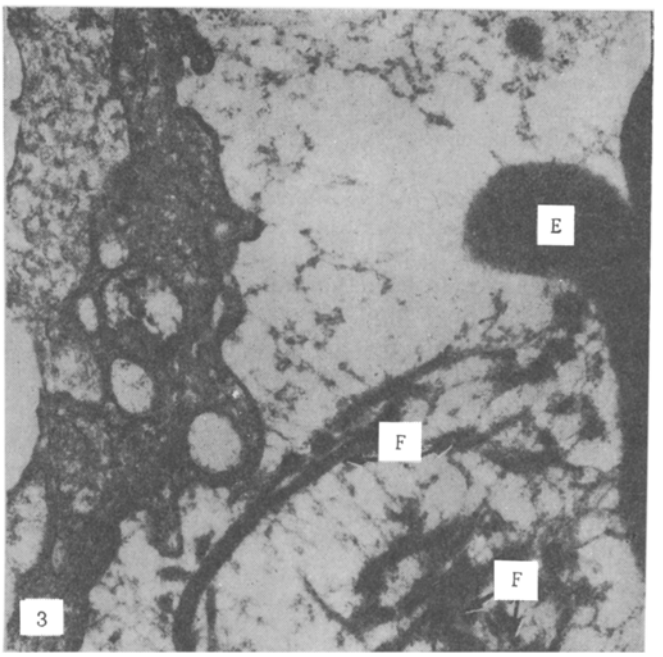

Fig. 3.

Fig. 2. State of hypophase of the lung surfactant 24 h after trauma: disorganization and lysis of membranous structures. Destruction of glycocalyx. Electron histochemistry. 20,000 x.

Fig. 3. Contents of alveolus 12 h after trauma: edema fluid, erythrocytes, fibrin threads (F). Electron micrograph. 14,000 x.

The development of HM also was preceded by changes in the lung surfactant. Destruction of the glycocalyx and disturbance of the ultrastructure of membranous formations of the surfactant, in the form of disorganization and fusion, were observed as early as 24 h after trauma (Fig. 2). Similar changes were observed until the end of the experiment, when the surfactant consisted mainly of felt-like, floccular, amorphous formations. A definite role in development of HM was played by disturbance of vascular permeability, as shown by changes in the organelles which were visible 1 h after the beginning of the experiment. The mitochondria appeared swollen, with an electron-translucent matrix, the cisterns of the endoplasmic reticulum were dilated, and the number of micropinocytotic vesicles was increased. These merged to form large vacuoles, evidence of vacuolar degeneration [3]. After 12 h lipid inclusions appeared in the endothelium a sign of profound disturbances of the endothelial cells [4]. Widening of the interendothelial junctions with exposure of BM also was observed.

Thus in respiratory failure due to chest injury, the formation of HM, constructed from fibrin and remnants of necrotic type I pneumocytes was observed after 72 h. Complex injuries to all elements of the air-blood barrier — endothelium, type I pneumocytes, lung surfactant — and also disturbances of the rheologic properties of the blood, in the form of sludging and the DIBC syndrome, and the development of interstitial edema all played a role in their development.

Interstitial edema, developing under conditions of increased capillary permeability, was observed as early as during the first hour, and after 12 h it was combined with intra-alveolar edema. Under these circumstances the lumen of the alveoli contained not only edema fluid, but also blood cells and fibrin threads among them (Fig. 3) and remnants of necrotic type I pneumocytes.

Changes in the rheologic properties of the blood, in the form of sludging and DIBC syndromes could contribute to the disturbance of permeability. A sludging syndrome develops as early as 1 h after the beginning of the experiment, whereas the DIBC syndrome developed after 6 h, and was manifested by the accumulation of platelets and agglutinated erythrocytes in the capillaries, with masses of fibrin among them.

LITERATURE CITED

1. S. P. Boikova, Byull. Éksp. Biol. Med., No. 4, 473 (1984).
2. L. K. Romanova and A. K. Boikov, Byull. Éksp. Biol. Med., No. 2, 105 (1974).
3. A. M. Chernukh and Yu. M. Shtykhno, Vestn. Akad. Med. Nauk SSSR, No. 10, 9 (1974).
4. V. A. Shakhlamov, The Capillaries (Electron-Microscopic Investigation) [in Russian], Moscow (1971).
5. M. Bachofen and E. R. Weibel, Am. Rev. Respir. Dist., 116, 589 (1977).
6. A. Dalquen, Pathol. Res. Pract., 165, 49 (1979).
7. M. S. Dunnil, Pulmonary Pathology, Edinburgh (1982).
8. A. F. Fishman, Circulation, 47, 921 (1973).
9. S. D. Greenberg, H. I. Schweppe, and M. Harness, Tex. Med., 72, 45 (1976).
10. J. H. Luft, Anat. Rec., 171, 347 (1971).
11. C. Mittermayer, U. N. Riede, and I. R. McEwan, Schrift. Intensivmed. Notfallmed. Anästhesiol., 16, 163 (1979).
12. S. R. Orell, Acta Pathol. Microbiol. Scand., 79 (A), 65 (1971).
13. G. G. Pietra, J. R. Rüttner, W. Wüst, and W. Glinz, J. Trauma, 21, 454 (1981).
14. U. N. Riede, C. Mittermayer, R. Horn, et al., Med. Welt (Stuttgart), 31, 491 (1980).
15. E. R. Weibel, Am. J. Roentgenol., 133, 1021 (1979).