Zaiats L.M., Klishch I.P., Zukow W. Ultrastructural organization of pulmonary hemomicrovasculature in case of experimental acute renal failure. Journal of Education, Health and Sport. 2018;8(3):382-388. eISNN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1204835
http://ojs.ukw.edu.pl/index.php/johs/article/view/5377

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part b item 1223 (26/01/2017).
1223 Journal of Education, Health and Sport eissn 2391-8306 7
© The Authors 2018;
This article is published with open access at Licensee Open Journal Systems of Kazimierz Wielki University in Bydgoszcz, Poland
Open Access. This article is distributed under the terms of the Creative Commons Attribution Noncommercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author (s) and source are credited. This is an open access article licensed under the terms of the Creative Commons Attribution Non commercial license (Http://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted, non commercial use, distribution and reproduction in any medium, provided the work is properly cited.
This is an open access article licensed under the terms of the Creative Commons Attribution Non commercial License (http://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted, non commercial use, distribution and reproduction in any medium, provided the work is properly cited.
The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 01.03.2018. Revised: 10.03.2018. Accepted: 21.03.2018.

ULTRASTRUCTURAL ORGANIZATION OF PULMONARY HEMOMICROVASCULATURE IN CASE OF EXPERIMENTAL ACUTE RENAL FAILURE

L.M. Zaiats[1], I.P. Klishch[1], W. Zukow[2]

[1]State institution of higher education "Ivano-Frankivsk National Medical University", Ivano-Frankivsk, Ukraine
e-mail: patfisiology@ifnmu.edu.ua

[2]Faculty of Earth Sciences, Nicolaus Copernicus University, Torun, Poland
e-mail: w.zukow@.wp.pl

Abstract

In our experiments on white male rats of Vistar line, we studied in dynamics (12, 24, 72 hours) the ultrastructural changes of pulmonary hemomicrovasculature in case of experimental acute renal failure. It has been determined that already in 12 hours after beginning of the experiment one can observe the ultrastructural constitution disorder of pulmonary hemomicrovasculature. In the capillary blood vessels of alveolar wall is determined the increased quantity of leukocytes, their adhesion and aggregation. With increase of the experimental period (24-72 hours), we have observed both dystrophic-destructive and compensatory-adaptive changes in pulmonary hemomicrovasculature.

Key words: lungs, hemomicrovasculature, experimental acute renal failure

Introduction

Nowadays, acute renal failure remains one of the most complicated problems of modern medicine. At present, the frequency of acute renal failure among population

approximates to 200 per 1 000 000 of people, moreover, it occurs 5 times more frequently in people of middle age as compared to young people [10]. The present pathology quite rarely occurs isolated. Major part of increased lethal outcome depends on extrarenal complications related to dysfunction of remote organs, and, in particular, lungs with development of acute respiratory distress syndrome [5, 7, 16, 17]. Lethality in case of the described pathology remains extremely high and constitutes 30-65 % [1, 2, 9, 11, 14]. In case of combination of acute renal failure and acute lung injury or acute respiratory distress syndrome frequent in critical patients, lethality reaches 80 % [8, 12].

The aim of the work was to study in dynamics the ultrastructural changes of pulmonary microvasculature in case of experimental acute renal failure.

Materials and methods

The experiments were done on 35 white male rats of Vistar line weighting 180-220 grams. Animals were divided into three groups: I – intact group of animals (n = 5); II – control (n = 15); III – group with modeled acute renal failure (n = 15).

Acute renal failure was induced by intramuscular administration of 50% glycerol water solution in dose of 10 ml per 1 kg of body mass [13]. The control group of animals was administered the equivalent volume of water for injections intraperitoneally.

The sampling of lung tissue for electron microscopy study was carried out under ketamine anaesthesia in 12, 24, 72 hours after beginning of the experiment. Pieces of lung tissue were fixed in 2,5% solution of gluteraldehyde with further postfixation in 1% solution of osmium tetroxide. After dehydration, the material was poured over epon araldite. The cuts, obtained on ultramicrotome “Tesla BS-490”, were studied using electron microscope “PEM-125K”.

Results and discussion

The electronic microscopic analysis carried out in 12 hours after beginning of the experiment has shown that the nuclei of some endotheliocytes of blood capillaries of interalveolar septum are increased in size. The nucleoplasm is filled with small granular matrix with predominant conglomeration of chromatin grains on periphery. The nuclear membrane forms superficial invaginations. The perinuclear space is dilated in some places. Mitochondria are characterized by matrix of weak electronic optical density and reduced cristas. At the same time, in some endothelial cells are observed small mitochondria with matrix of moderate electronic optical density. In the perinuclear zone is determined the Golgi

apparatus (GA) presented by somewhat dilated cisterns and vesicles. The ducts of granular endoplasm grid (GEG) are dilated, on the outer surface of their membranes we have observed reduced quantity of ribosomes. The basal membrane is thickened without distinct contours. In the lumina of some blood capillaries is noted the increased quantity of neutrophilous leucocytes, their adhesion and aggregation (Fig. 1).

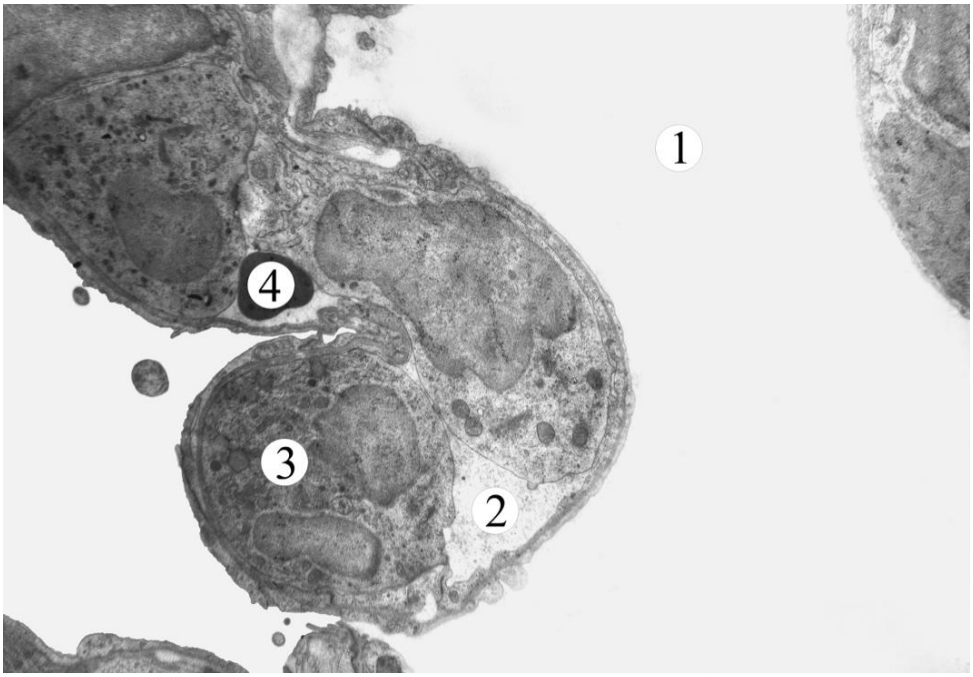

Fig. 1. Adhesion and aggregation of leukocytes in blood capillaries of alveolar wall in 12 hours after beginning of the experiment.
1 – alveolar lumen; 2 – blood capillary lumen; 3 – leukocyte; 4 - erythrocyte
Electronic microphotography x 4 000.

In 24 hours after beginning of the experiment, the cytoplasm of endothelial cells is characterized by low electronic optical density. The nuclei of cells have oval form and are increased in size. In majority of endothelial cells, the chromatin grains are located along the internal surface of the nuclear membrane or grouped into individual clusters. The perinuclear space is dilated. Mitochondria have cleared matrix and disorganised cristas. We have also observed partial destruction of mitochondria. Along with the dilated components of GA is observed GEG membranes fragmentation. The quantity of ribosomes is sharply reduced. Basal membrane is thickened on its whole duration with unclear contours and has uneven electronic optical density. In some capillary blood vessels, we observed the endothelial cells'

luminal membrane integrity disorder that is accompanied by intracellular content coming out into the micro vessel lumen. The referred research period is characterized by presence of adhesion and aggregation of leukocytes and thrombocytes, erythrocyte aggregates in the capillary blood vessels lumen (Fig. 2).

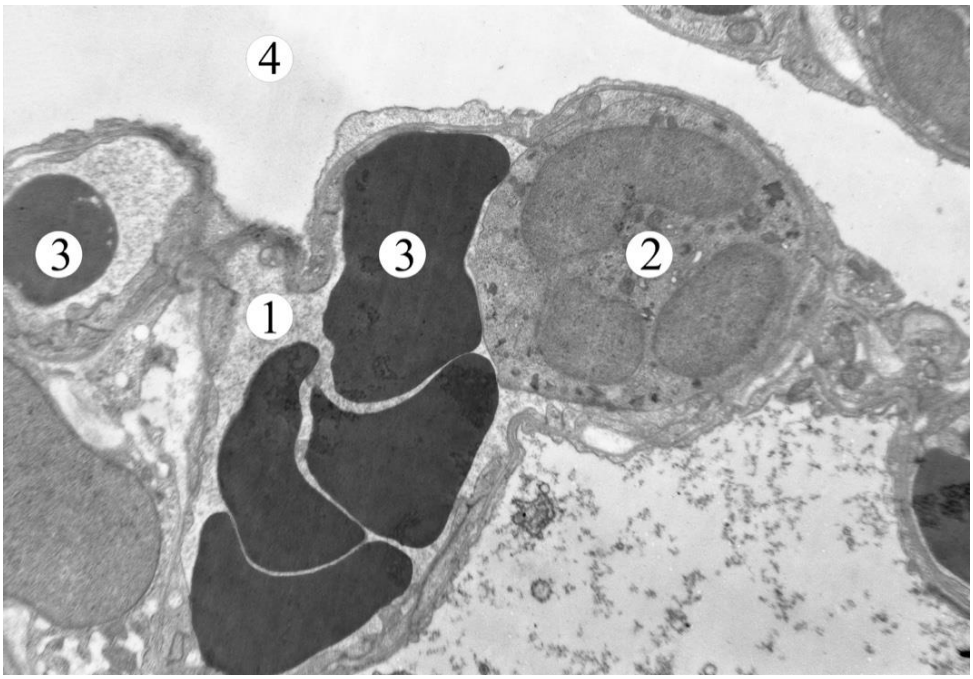

Fig. 2. Ultrastructural organization of blood capillary alveolar wall in 24 hours after beginning of the experiment.
1 – blood capillary lumen; 2 – leukocyte; 3 – erythrocyte; 4 – alveolar lumen.
Electronic microphotography x 4 800.

In 72 hours after the beginning of research, the edematic phenomena in endothelial cells are retained. The nuclei of cells have cleared matrix. The mitochondria are rare, with vacuole transformation, some of them are destroyed. The cisterns and canals of GA and GEG are sharply dilated. Basal membrane has unclear contours and uneven electronic optical density. In the peripheral zones of endothelial cells are noted micropinocytotic vesicles and vacuoles. In the lumen of capillary blood vessels is detected adhesion and aggregation of leukocytes and thrombocytes. On the luminal surface of endothelial cells are observed the folders of cytoplasm areas without nuclei that protrude into the lumen of capillary blood vessels. In some endothelial cells, its protrusions in the form of velum are noted on the luminal surface of cell membrane. At the same time, are detected some endothelial cells with nuclei of average electronic optical density. The chromatin grains are evenly placed on the

whole area of the nucleus. The nuclear membrane has clear contours and invaginations. In the perinuclear space, we can localize GA represented by small vesicles and vacuoles. The mitochondria are different in size and form with matrix of average electronic optical density. The GEG canals are hypertrophic; the quantity of ribosomes on their membranes is retained. In the peripheral compartments of endothelial cells, we have observed the increased quantity of micropinocytotic vesicles. On the luminal surface of some endothelial cells are defined microfibers that protrude into the lumen of capillary blood vessels. The basal membrane retains the characteristic structure on the whole duration. The zones of contact between the endothelial cells remain unaltered.

The realized research has demonstrated that the microcirculation in lungs has been impaired already in 12 hours after acute renal failure modelling. In the lumen of blood capillaries of the alveolar wall, we observed the increased quantity of neutrophil leukocytes as well as their aggregation and adhesion to endotheliocytes. The changes of similar nature are pinpointed by some other researchers who studied the condition of pulmonary tissue exposed to exo- and endogenic factors [11, 16]. The activation of neutrophils happens as a result of previous influence on cells of thrombocytes activation factor, complement components C3a and C5a, leukotrienes, IL-8, TNF-alpha, granulocyte-macrophage colony-stimulating factor [6, 15]. It is known that activated neutrophils and their interaction with endothelium include adhesion, aggregation and their further degranulation. The neutrophil degranulation leads to collapse of vascular endothelium architecture by proteolytic enzymes such as elastase, gelatinase and collagenase, and some time later, to destruction of vascular wall integrity as elastase ruins the cadherine connections between endotheliocytes [6, 8, 11]. Taking into consideration the above described and other research results [3, 4, 6], one can affirm that changes of pulmonary hemomicrovasculature in case of experimental acute renal failure play the main role in the development of acute lung injury.

Conclusions

1. The realized research has demonstrated that experimental acute renal failure is accompanied by submicroscopic changes of pulmonary hemomicrovasculature.
2. The alteration of ultrastructural organization of pulmonary hemomicrovasculature is observed already in 12 hours after beginning of the experimental study.

REFERENCES

1. Chen C, Shi L, Li Y, Wang X, Yang S. Disease-specific dynamic biomarkers selected by integrating inflammatory mediators with clinical informatics in ARDS patients with severe pneumonia. Cell Biol Toxicol. 2016; 32: 169-84.

2. Dobrorodniy A.V. Condition of lipids peroxidation, antioxidant system, humoral elements of immune defence and endogenous intoxication on the background of experimental acute respiratory distress syndrome in rats. Bulletin of Scientific Research. 2011; 3:99-101. [in Ukrainian]

3. Elshall LM, Amer MG, Abd El-Haleem MR. Histological changes induced by experimental renal failure in the lung of adult male albino rats and the role of melatonin supplementation. Egypt.J.Histol. 2009; 32(2): 391-400.

4. Golubev AM, Moroz VV, Sundukov DV. Pathogenesis of acute respiratory distress syndrome. General reanimatology. 2012; 8(4): 13-21. [in Russian]

5. Grams ME, Rabb H. The distant organ effects of acute kidney injury. Kidney International. 2012; 81: 942-8.

6. Kassil V.L. Acute extrapulmonary respiratory distress syndrome: definition, etiopathogenesis, clinical and laboratory manifestations (review of literature with elements of criticism). Clinical oncohematology. 2011; 4 (1): 54-65. [in Russian]

7. Klein CL, Hoke TS, Fang W, Altmann CJ, Douglas IS, Faubel S. Interleukin-6 mediates lung injury following ischemic acute kidney injury or bilateral nephrectomy. Kidney International. 2008; 74: 901-9.

8. Ko GJ, Rabb H, Hassoun HT. Kidney-lung crosstalk in the critically ill patient. Blood Purif. 2009; 28: 75-83.

9. Liu KD, Glidden DV, Eisner MD, Parsons PE, Ware LB, Wheeler A et al. Predictive and pathogenetic value of plasma biomarkers for acute kidney injury in patients with acute lung injury. Crit Care Med. 2007; 35(12):2755-61.

10. Markina AY, Tyupka TI. The impact of indolinoren on the experimental acute renal failure. Ukrainian biopharmaceutical journal. 2013; 2(25): 50-3. [in Ukrainian]

11. Marushchak MI. The level of correlation between reactive oxygen species, neutrophils content and blood gases in experimental acute lung injury. Scientific bulletin of Uzhhorod university series medicine. 2012; 1(43): 9-12. [in Ukrainian]

12. Petrenko OV, Zakon KM, Dudarenko VB. Combined acute lung and renal injury. Ukrainian journal of nephrology and dialysis. 2010; 4(28): 45-61. [in Ukrainian]

13. Rodrigo R, Trujillo S, Bosco C. Biochemical and ultrastructural lung damage indused by rhabdomyolysis in the rat. Exp.Biol.Med. 2006; 231: 1430-8.
14. Voytkovskaya KS, Cherniaev AL. Acute lung injury: the definition, pathogenesis, animal models and the role of mesenchymal stem cells in experimental treatment. The Bulletin of Contemporary Clinical Medicine. 2012; 5(2): 60-8. [in Russian]
15. Williams A, Chambers R. The mercurial nature of neutrophils: still an enigma in ARDS? Am J Physiol Lung Cell Mol Physiol. 2014; 306: 217-30.
16. Yap SC, Lee HT Acute kidney injury and extrarenal organ dysfunction. Anesthesiology. 2012; 166(5): 1139-48.
17. Zhao H, Huang H, Ologunde R, Lloyd DG, Watts H, Vizcaychipi MP et al. Xenon treatment protects against remote lung injury after kidney transplantation in rats. Anesthesiology. 2015; 122(6): 1312-26.