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ULTRASTRUCTURAL ORGANIZATION OF ALVEOLAR MACROPHAGES DURING LATE DEVELOPMENT OF EXPERIMENTAL ACUTE PANCREATITIS

Liubomyr Zaiats[1], Olga Pasichnyk[1], Walery Zukow[2]
https://orcid.org/0000-0003-3265-1273
https://orcid.org/0009-0005-0272-2378
https://orcid.org/0000-0002-7675-6117

[1] Ivano-Frankivsk National Medical University, Ivano-Frankivsk, Ukraine
patfisiology@ifnmu.edu.ua
[2] Nicolaus Copernicus University, Torun, Poland w.zukow@wp.pl

Abstract

Background. Nowadays, acute pancreatitis continues to remain an actual problem both in surgery and in intensive care medicine. **The aim of the work** was to study the dynamics of ultrastructural changes of alveolar macrophages in the long-term development of experimental acute pancreatitis. **Material and methods.** The experiments were carried out on 62 white Wistar male rats weighing 180–220 g. The animals were divided into three groups: first — intact, second — control, third — experimental with a model of acute pancreatitis, which was reproduced by intraperitoneal administration of a 20% solution of L-arginine in a total dose of 5 g/kg at one-hour interval. The control group of animals was intraperitoneally injected with an equivalent dose of isotonic sodium chloride solution. All research were performed under sodium thiopental anesthesia at the rate of 60 mg/kg body weight. Lung tissue for electron microscopic examination was collected from the lower lobe of the left lung at 3–5 and 7 days. Pieces of lung tissue measuring 1×1×1 mm were fixed in a 2.5% glutaraldehyde solution, followed by additional fixation in a 1% osmium tetroxide solution. After dehydration, the material was poured into Epon-Araldite. Sections with a thickness of 20–50 nm obtained on "Tesla BS-490" ultramicrotome were studied in a PEM-125K electron microscope. **Results.** It was found that three days after the start of the study, significant heterogeneity of alveolar macrophages was observed in the alveolar lumen. Next to active phagocytic macrophage elements with dystrophic-destructive changes are determined. Continuation of the experiment (5 days) leads to the progression of submicroscopic changes in alveolar macrophages, which are most pronounced on the7 day of the study. **Conclusion.** Acute experimental pancreatitis is accompanied by pronounced changes in the ultrastructural structure of alveolar macrophages. The features and severity of structural changes in alveolar macrophages depends on the duration of arginine-induced acute pancreatitis.

Key words: arginine-induced acute pancreatitis, lungs, alveolar macrophages.

INTRODUCTION

Nowadays, acute pancreatitis (AP) continues to be an actual problem both in surgery and in intensive care medicine [2, 5, 8, 11]. Actuality of this problem is primarily due to a significant increase in the number of patients with acute pancreatitis, which even today occupies a leading place among acute surgical diseases of the abdominal cavity [3, 6, 7, 12, 15]. Among the consequences of acute pancreatitis are disorders due to changes in the protective properties of the lungs, the cellular link of local immunity, which is represented by alveolar macrophages (AMs) [1, 4, 10, 13, 14].

The aim of the work was to study the dynamics of ultrastructural changes of alveolar macrophages in the long-term development of experimental acute pancreatitis.

MATERIAL AND METHODS

The experiments were carried out on 62 white Wistar male rats weighing 180–220 g. The animals were divided into three groups: first — intact, second — control, third — experimental with a model of acute pancreatitis, which was reproduced by intraperitoneal administration of a 20% solution of L-arginine in a total dose of 5 g/kg at one-hour interval. The control group of animals was intraperitoneally injected with an equivalent dose of isotonic sodium chloride solution. All research

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RESULTS AND DISCUSSION

The submicroscopic analysis carried out three days after the start of the study showed that there is significant heterogeneity of alveolar macrophages in the alveoli. Along with actively phagocytizing AMs, macrophage elements with dystrophic-destructive changes were observed (Figure 1). The nuclei of many alveolar macrophages with fine-grained nucleoplasm of low electron-optical density. Chromatin granules in most cases are located along the inner surface of the nuclear membrane. The nucleolem has winding contours and forms not deep intussusceptions. The perinuclear space is expanded. Mitochondria of different sizes and shapes with individual disoriented crista. The Golgi complex (GC) is represented by expanded cisterns and small and large bubbles. Tubules of the GER are hypertrophied. The number of ribosomes on their outer membrane is reduced. In some alveolar macrophages, there is fragmentation of the membrane of the GER. The number of lysosomes is slightly reduced. Along with this, separate phagosomes with fragments of lamellar bodies and destroyed cells are observed.

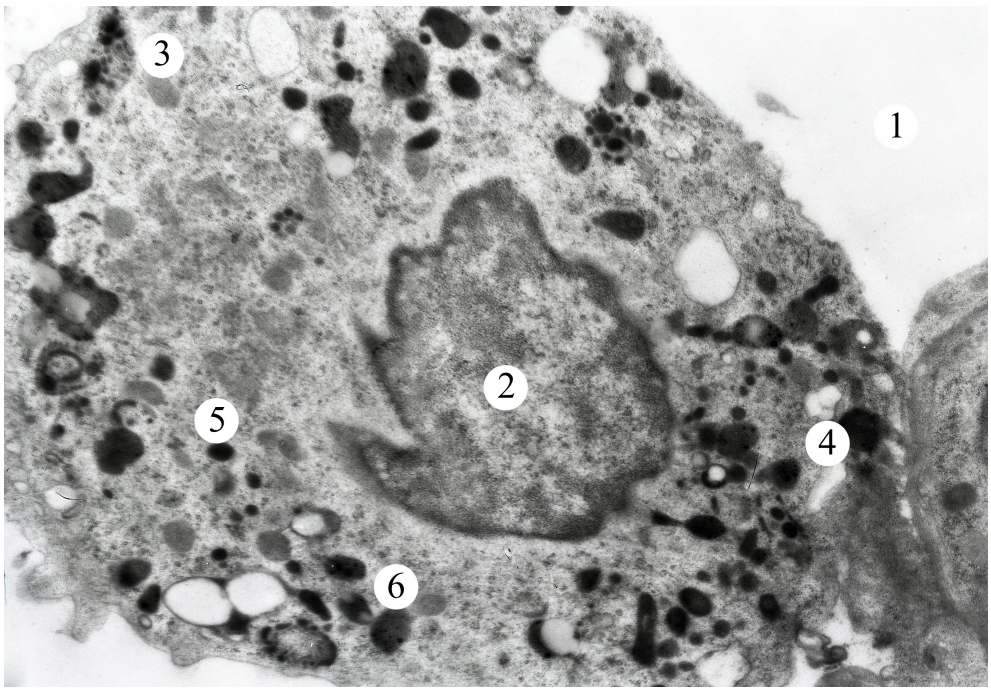

Fig. 1. Ultrastructural changes of the alveolar macrophage three days after the start of the experiment. Electron microphotograph x6400.

Marking: 1 – alveolar lumen; 2 – nucleus; 3 – mitochondrion; 4 – granular endoplasmic reticulum; 5 – lysosome; 6 – phagosome.

With an increase in the duration of the study (5 days), the nuclei of AM are increased in volume with a matrix of low electron-optical density and marginal placement of chromatin granules. The perinuclear space is expanded. Mitochondria are enlarged in volume with a lightened matrix and disoriented cristas. The components of the CG are swollen and disoriented. Along with expanded tubules of the granular endoplasmic reticulum, fragmentation of its membrane is detected. A decrease in the number of lysosomes is also observed. As at the previous stage of the study, fragments of lamellated corpuscles (LCs) and destroyed cells are detected in the phagosomes. For the current period of the study, the accumulation of macrophage elements with large phagosomes is noted in individual alveoli.

The submicroscopic analysis showed that after 7 days of research, the nuclei of many alveolar macrophages had a matrix of low electron-optical density and marginal aggregation of chromatin granules. In some cells, chromatin granules are grouped into separate clumps. The perinuclear space is expanded. Mitochondria with a lightened matrix and single shortened cristas. Mitochondrial destruction is also observed. In the perinuclear zone, disorientation of the Golgi apparatus components is noted. Lysis of their membranes is observed in individual macrophage elements along with dilated tubules of the granular endoplasmic reticulum. The number of ribosomes on their outer membrane is reduced. Lysosomes are represented by single granules. Separate phagosomes with polymorphic osmiophilic material are also detected in the cytoplasm.

Data of ultrastructural research have shown that acute arginine-induced pancreatitis is characterized by pronounced disturbances of the ultrastructural organization of alveolar macrophages. The presence of agglomeration of macrophage elements in the alveoli shows their functional deficiency, which is indicated by a number of other researchers under the influence of exogenous and endogenous factors [9, 10, 13, 14].

CONCLUSION

Acute experimental pancreatitis is accompanied by pronounced changes in the ultrastructural structure of alveolar macrophages. The features and severity of structural changes in alveolar macrophages depends on the duration of arginine-induced acute pancreatitis.

REFERENCES

1. Aberclein JD, Cole J, Bewley MA, Marriott HM, Dockrell DH. Alveolar macrophages in pulmonary host defence - the unrecognized role of apoptosis as a mechanism of intracellular bacterial killing. British Society for Immunology, Clinical and Experimental Immunology.2013;174:193-202.

2. Gukovskaya AS, Gukovsky I, Algul H, Habtezion A. Autophagy, Inflammation, and Immune Dysfunction in the Pathogenesis of Pancreatitis. Gastroenterology. 2017;153(5):1212-1226. doi:10.1053/j.gastro.2017.08.071.

3. Isaji S, Takada T, Mayumi T, Yoshida M, Wada K, Yokoe M. Revised Japanese guidelines for the management of acute pancreatitis 2015: revised concepts and updated points. Hepatobiliary Pancreat. Sci. 2015;22(6):433-445.

4. Johnston LK, Rims CR, Gill SE, McGuire JK, Manicone AM. Pulmonary macrophage subpopulations in the induction and resolution of acute lung injury. American Journal of Respiratory Cell and Molecular Biology. 2012;47(4): 417-426.

5. Kumar P, Gupta P, Ranar S. Thoracic complications of pancreatitis. JGH Open: An open access journal of gastroenterology and hepatology. 2019;3:71-79. doi:10.1002/jgh3.12099

6. Lankisch PG, Apte M. Banks PA. Acute pancreatitis. Lancet. 2015;386:85-96. doi:10.1016/S0140-6736(14)6U649-8.

7. Leppaniemi A, Tolonen M, Tarasconi A, Segovia-Lohse H, Gamberini E, Kirkpatrick AW, et al. 2019 WSES guidelines for the management of severe acute pancreatitis. World Journal of Emergency Surgery. 2019; 14:27 https://doi.org/10.1186/s13017-019-0247-0.

8. Liu D, Wen L, Wang Z, Hai Y, Yang D, Zhang Y, et al. The Mechanism of Lung and Intestinal Injury in Acute Pancreatitis: A Review. Frontiers in Medicine. 2022;9:Article 904078.

9. Machado-Aranda D, Suresh MV, Dolgachev BY, Hemmila MR, Raghavendran K. Alveolar macrophage depletion increases the severity of acute

inflammation following nonlethal unilateral lung contusion in mice. Journal of Trauma and Acute Care Surgery. 2014; 76(4):982-990.

10. Nebesna ZM. Structural reorganization of alveolar macrophages of the respiratory part of lungs in dynamics after experimental thermal trauma and in the conditions of use of granulated medium of freeze-dried xenoskin. Bulletin of Biology and Medicine Issues. 2015; 3(2):305-9.

11. Phillip V, Steiner JM, Algul A. Early phase of acute pancreatitis: assessment and management. World J. Gastrointest. Pathophysiol. 2014;5:158-64.

12. Yin T, Peeters R, Liu Y, Feng Y, Zhang X, Jiang Y, et al. Visualization, Quantification and Characterization of Caerulein-Induced Acute Pancreatitis in Rats by 3.0T Clinical MRI, Biochemistry and Histomorphology. Theranostics. 2017; 7(2):285-294.

13. Zaiats LM, Klishch IP. Ultrastructure of alveolar macrophages in case of experimental acute renal failure. World of medicine and biology. 2018;1(63):130-133.

14. Zaiats LM, Savchuk RM. Ultrastructure of alveolar macrophages under conditions of industrial pollution of the atmosphere. Reports of Morfology. 2014;1(20):113-116.

15. Zerem E. Treatment of severe acute pancreatitis and its complications. World J. Gastroenterol. 2014;20(38):13879-13892.