3. L. A. Ioffe, A. V. Korobkov, L. A. Lantsberg, and E. I. Fel'shina, Kosmich. Biol., 5, 15 (1971).
4. E. A. Kovalenko, V. L. Popkov, Yu. I. Kondrat'ev, et al., Patol. Fiziol., 14, 3 (1970).
5. M. M. Kolpakov, in: Adaptation to Muscular Activity and Hypokinesia [in Russian], Novosibirsk (1970), p. 89.
6. D. Cardus, C. Vallbona, F. B. Vogt, et al., Aerospace Med., 36, 524 (1965).
7. R. Fuchs-Hammoser, M. Schweiger and W. Oelkers, Acta Endocrinol., 87, Suppl. 215, 22 (1978).
8. N. Goncharov, A. G. Taranov, A. V. Antonichev, et al., Acta Endocrinol., 90, 372 (1979).
9. W. Hubl and G. Dorner, Acta Endocrinol., 91, Suppl. 225, 341 (1979).
10. F. H. Katz, Aerospace Med., 35, 849 (1964).
11. T. J. McKenna, D. D. Island, W. E. Nicholson, et al., Acta Endocrinol., 90, 122 (1979).
12. J. Müller, Endocrinology, 103, 2061 (1978).
13. M. G. Nichols, E. A. Espiner, and R. A. Donald, J. Clin. Endocrinol. Metab., 41, 186 (1975).
14. C. A. Nugent and D. M. Mayes, J. Clin. Endocrinol. Metab., 26, 1116 (1966).

PHAGOCYTIC AND LYMPHOID CELLS IN TISSUE REACTIONS TO ASEPTIC INFLAMMATION

L. V. Yashchenko

UDC 616-002-021.4-07:616.155.3-008.13-076.5

KEY WORDS: inflammation; macrophages; polymorphonuclear leukocytes; lymphocytes; tissue processes.

A previous investigation [1] showed that injury to macrophages, polymorphonuclear leukocytes (polymorphs), and lymphocytes initiates the development of inflammatory changes. The object of the present investigation was to study the connection between the state of these cells and the character of tissue inflammatory changes with special reference to aseptic inflammation.

EXPERIMENTAL METHOD

A sterile nylon thread 0.7 mm in diameter and 15 cm long was introduced into the peritoneal cavity of 20 rabbits. The development of inflammation was studied 3 days, 2 weeks, and 2 and 4 months later (in five animals at each time). Twelve healthy rabbits served as the control.

Squash preparations from the peritoneal cavity and trachea and blood films were stained with hematoxylin–eosin. Deoxyribonucleoproteins (DNP, by Feulgen's method), ribonucleoproteins (RNP, by Brachet's method), total protein (by mercuric chloride and bromphenol blue), and activity of NAD-diaphorase (with nitro-BT) and acid phosphatase (by Burstone's method) were determined in them. Squash preparations from the peritoneal cavity also were stained by Gram's method. In films stained with hematoxylin and eosin the cell composition in per cent was calculated and the number of destroyed cells counted. When films in which acid phosphatase was found were assessed, activity of the enzyme was determined and the permeability of the lysosomal membranes was estimated from the number of cells with a diffuse type of distribution of the reaction product [2]. In each of 600 films at least 100 cells were assessed by means of a point system, and the mean cytochemical index (MCI) was calculated and the results subjected to statistical analysis to determine significant differences by Student's t-test ($n < 30$). Tissue of the capsule formed around the foreign body in the peritoneal cavity and lung tissue were investigated histologically.

EXPERIMENTAL RESULTS

The development of aseptic (confirmed by bacterioscopy) intraperitoneal inflammation after introduction of the foreign body was accompanied by three stages of changes in the macrophages, polymorphs, and lympho-

Experimental Laboratory, I. M. Sechenov Research Institute of Physical Methods of Treatment and Medical Climatology, Yalta. (Presented by Academician of the Academy of Medical Sciences of the USSR A. M. Chernukh.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 90, No. 12, pp. 666-668, December, 1980. Original article submitted May 27, 1980.

0007-4888/80/9012-1657$07.50

TABLE 1. Changes in Peritoneal Macrophages, Polymorphs, and Lymphocytes during Aseptic Intraperitoneal Inflammation (conventional units, M ± m)

Indices (MCI)	Cells	Time of investigation				
		control	3 days	2 weeks	2 months	4 months
DNP content	Macrophages	0,97	0,45±0,15	0,33	0,89	0,78
	P		<0,01			
	Polymorphs	0,87	0,56±0,071	0,34	0,9	0,82
	P		<0,01			
	Lymphocytes	0,96	0,51±0,075	0,37	0,89	1,09
	P		<0,01			
RNP concentration	Macrophages	1,21	0,92±0,073	0,92	1,02	—
	P		<0,02			
	Polymorphs	1,13	0,88±0,072	0,87	1,38	—
	P		<0,02			
	Lymphocytes	1,25	0,86±0,066	1,03	1,43	—
	P		<0,001			
Protein concentration	Macrophages	0,58	0,55	0,42±0,063	0,58	0,47
	P			<0,05		
	Polymorphs	0,66	0,44	0,46±0,02	0,6	0,39
	P			<0,001		
	Lymphocytes	0,69	0,53±0,09	0,46	0,67	0,42
	P		<0,05			
NAD-Diaphorase activity, MCI	Macrophages	2,59	2,48	2,26±0,071	2,66	1,95
	P			<0,01		
	Polymorphs	2,1	2,02	2,07	2,49±0,13	1,45
	P				<0,05	
	Lymphocytes	2,62	2,18±0,08	1,92	2,21	1,86
	P		<0,01			
Acid phosphatase activity	Macrophages	0,75	1,12	0,98±0,017	0,76	0,67
	P			<0,001		
	Polymorphs	0,65	0,81±0,063	0,85	0,95	0,58
	P		<0,05			
	Lymphocytes	0,84	0,89	0,8	0,9	0,74
	P					

TABLE 2. Injury to Peritoneal Macrophages, Polymorphs, and Lymphocytes during Aseptic Intraperitoneal Inflammation

Indices	Cells	Time of investigation				
		control	3 days	2 weeks	2 months	4 months
Number of cells with diffuse acid phosphatase (%)	Macrophages	23,76	61,36	79,85±0,05	79,12	82,53
	P			<0,001		
	Polymorphs	0	46,82	72,19	31,66	0
	Lymphocytes	20,66	21,66	51,0±2,24	60,0	62,49
	P			<0,001		
Number of destroyed cells (%)	Macrophages	35,5	50,98	59,34	67,11	72,2
	Polymorphs	Single	18,42	18,66	10,82	H10,0
	Lymphocytes	Single	18,16	26,14	20,0	27,9

cytes of the peritoneal exudate (Tables 1 and 2). In the first stage (3 days to 2 weeks) the content of DNP, RNP, and protein, and NAD-diaphorase activity (except in polymorphs) were reduced, acid phosphatase activity was increased (in macrophages and polymorphs only), and the number of cells with increased permeability of the lysosomal membranes was increased. In the second stage (2 months) the DNP content, RNP and protein concentrations, and NAD-diaphorase activity were increased compared with previously, whereas acid phosphatase activity was reduced (only in the macrophages). The percentage of polymorphs with destabilized lysosomal membranes was reduced. The third stage (4 months) was characterized by a second decrease in the protein concentration in the macrophages, polymorphs, and lymphocytes, and a decrease in NAD-diaphorase and acid phosphatase activity (compared with 2 months). Throughout the period of inflammation the number of destroyed cells, especially macrophages and lymphocytes, increased significantly.

Similar changes were found in polymorphs and lymphocytes of the blood and macrophages, polymorphs, and lymphocytes of the trachea. They were less severe, however. In the blood polymorphs in the first stage only the RNP concentration (from 0.97 to 0.73 conventional unit; $P < 0.001$) and NAD-diaphorase activity (from 1.76 to 1.47 conventional units; $P < 0.05$) were significantly reduced. At the other two stages the changes in the polymorphs and at all three stages changes in the state of the lymphocytes were nothing more than a tendency.

TABLE 3. Changes in DNP in Macrophages, Polymorphs, and Lymphocytes of the Trachea during Aseptic Intraperitoneal Inflammation

Indices	Cells	Time of investigation				
		control	3 days	2 weeks	2 months	4 months
DNP content, MCI	Macrophages	0,89	0,66	0,71	1,09	0,68
	Polymorphs	0,9	0,66±0,15	0,66	1,14	0.77
	P		<0,01			
	Lymphocytes	0,83	0,54±0,09	0,76	1,17	1,0
	P		<0,02			

Significant changes at all three stages in the macrophages, polymorphs, and lymphocytes of the trachea affected only the DNP content (Table 3). Changes in the other indices amounted only to a tendency, although three stages could still be distinguished. After 4 months there was a significant increase in the percentage of macrophages (from 45.99 to 90.66), polymorphs (from 24.55 to 66.8), and lymphocytes (from 28.99 to 74.1) in the trachea, together with an increase in the permeability of the lysosomal membranes. Increases also were observed at this time in the percentage of destroyed macrophages (from 22.66 to 57.7) and lymphocytes (from 8.33 to 20.0). In all cases the difference was significant ($P < 0.001$). Changes in these indices at earlier periods amounted only to a tendency.

The similarity of the changes in different types of cells (macrophages, polymorphs, and lymphocytes) at each of the stages in different situations (peritoneal cavity, blood, trachea) indicates structural and functional reorganization at the level of the system as a whole. Differences in the severity and time of onset of the changes depending on the location of the cells and their type were evidently attributable to reorganization at the regional and cellular levels.

Histological investigation of the tissue of the capsule formed around the foreign body introduced into the peritoneal cavity and of the lung tissues of the same animals showed that changes in the macrophages, polymorphs, and lymphocytes at each of the above-mentioned stages corresponded to tissue inflammatory changes of a definite character.

According to the results, particular features of the first stage of reorganization (compared with the control) include a decrease in parameters of biosynthesis (DNP, RNP, protein, NAD-diaphorase), activation of acid phosphatase, and injury (increased permeability of lysosomal membranes, destruction) of macrophages, polymorphs, and lymphocytes. The development of tissue reactive and oxidative processes proceeded correspondingly. In the capsule they are characterized by the accumulation of macrophages, lymphocytes, and their breakdown products on the surface of the nylon thread, and in the lungs by small foci of desquamation of the bronchial epithelium, moderate edema, and infiltration of macrophages around the small vessels of the alveolar tissue.

Particular features of the second stage of reorganization (compared with the first) include an increase in the parameters of biosynthesis, a reduction in acid phosphatase activity, and continuation of injury to macrophages, polymorphs, and lymphocytes. This is reflected in the addition of proliferative processes to the reactive and exudative changes taking place previously. In the capsule, under these circumstances, loose fibrous connective tissue may be seen to be formed, and in the lungs there is moderate hyperplasia of the peribronchial lymphoid follicles.

The third stage of reorganization (compared with the second) is marked by a second decrease in the parameters of biosynthesis and acid phosphatase activity, while injury to the three types of cells studied persists. This corresponds to the development of proliferative processes in the capsule, leading to transformation of the loose fibrous connective tissue into dense tissue without any regular orientation. Changes in the inflammatory processes in the lungs at this stage are minimal.

The structural and functional reorganization of macrophages, polymorphs, and lymphocytes arising in aseptic inflammation are thus connected with the developing local (capsule) and distant (lungs) tissue inflammatory changes. Injury to these cells reflects the development of reactive and exudative processes, whereas changes in the parameters of biosynthesis reflect the development of tissue proliferative processes.

LITERATURE CITED

1. L. V. Yashchenko, Byull. Éksp. Biol. Med., No. 5, 620 (1977).
2. L. Bitensky, R. Butcher, and J. Chagen, in: Lysosomes in Biology and Pathology, edited by J. T. Dingle and H. B. Fell, Amsterdam (1973), pp. 465-510.