ROLE OF THE MESOTHELIUM OF THE PARIETAL PERITONEUM IN ABSORPTION OF TRUE SOLUTIONS AND AN INK SUSPENSION FROM THE PERITONEAL CAVITY

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Absorption of hypotonic, physiological, and hypertonic solutions and of an ink suspension in physiological saline from the peritoneal cavity was studied by an electron-microscopic method. Pinocytosis was estimated quantitatively on electron micrographs. The passage of true solutions through the mesothelium was shown to take place diffusely through the cytoplasm of its cells and along the intercellular spaces, whereas the ink suspension passed only along open intercellular spaces. Pinocytosis in mesothelial cells takes place from the basal part toward the apex and is aimed at equalizing the concentration of the protein and salt composition of the serous fluid.
KEY WORDS: mesothelium of parietal peritoneum; absorption; pinocytotic vesicles.

Many investigations have been made of absorption of various solutions through serous membrane, but there is no general agreement regarding the role of the mesothelium in this process. According to data in the literature, absorption of solutions (true and colloidal) and suspensions from serous cavities can take place by diffusion through the mesothelial cells [1, 5], by micropinocytosis [2, 4, 6-8], and via the intercellular spaces [2, 3].

The object of this investigation was to study the role of the mesothelium of the parietal peritoneum in the absorption of certain true solutions changing the composition of the serous fluid, and of an ink suspension.

EXPERIMENTAL METHOD

The mesothelium of the parietal peritoneum of albino mice was used as the test object. There were four series of experiments. In series I the animals were given an intraperitoneal injection of hypotonic solution (2 ml distilled water), in series II they received 2 ml of physiological saline, in series III a hypertonic solution (0.2 ml 20% sodium chloride solution), and in IV 2 ml of a 30% suspension of black ink in physiological saline. At intervals of 5, 10, 20, 30, and 60 min after injection of the solutions the parietal peritoneum was fixed in 1% osmium by Caulfield's method for 2 h and embedded in Araldite. Sections cut on the LKB-3 ultratome were studied in the IEM-7A electron microscope. The number of pinocytotic vesicles in the apical and basal parts of the cell per 1 μ of plasma membrane, the length of which was measured by the KU-A curvimeter, was counted on electron micrographs produced under an instrumental magnification of 20,000-30,000 ×. All pinocytotic vesicles connected with the plasma membrane or at a distance from it equal to the mean diameter of a vesicle (70 nm) or less were counted. The true length of the plasma membrane was determined by the equation: $A = A_{ph} \cdot 1000/M$, where A is the true length of the plasma membrane (in μ); A_{ph} the length of the membrane on the photograph (in mm); M the magnification of the microscope. For each morphometric investigation electron micrographs of 20-25 mesothelial cells prepared from arbitrarily chosen blocks and sections were studied. The numerical results were subjected to statistical analysis.

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TABLE 1. Number of Pinocytotic Vesicles near Plasma Membrane (to 1 μ of length of membrane) in Apical (A) and Basal (B) Parts of Cell (M ± m)

Time after injection of solution, min	Hypotonic solution		Physiological solution		Hypertonic solution		30% ink suspension in physiological solution	
	A	B	A	B	A	B	A	B
5	1,9±0,040	3,5±0,048	2,2±0,121	4,7±0,209	0,5±0,035	1,7±0,041	1,7±0,124	2,5±0,114
10	1,2±0,096	4,0±0,212	2,1±0,091	3,5±0,093	1,4±0,124	2,2±0,072	2,0±0,076	4,1±0,170
20	1,4±0,092	3,8±0,174	2,5±0,105	4,2±0,261	0,6±0,049	2,5±0,170	3,3±0,105	4,7±0,086
30	1,7±0,046	4,0±0,155	1,9±0,060	5,1±0,178	0,6±0,021	1,8±0,067	2,5±0,104	3,8±0,107
60	1,2±0,106	3,6±0,205	1,8±0,168	2,5±0,148	0,8±0,051	1,4±0,026	2,6±0,208	2,0±0,069
Control	A — 1,1± ±0,064				B — 1,4± ±0,089			

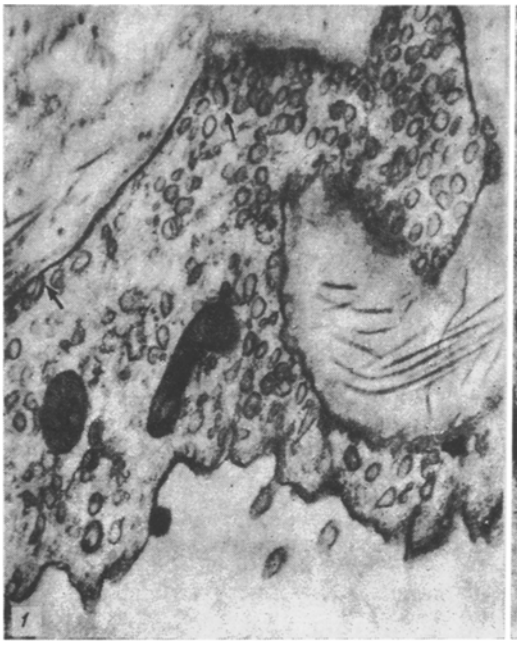

Fig. 1

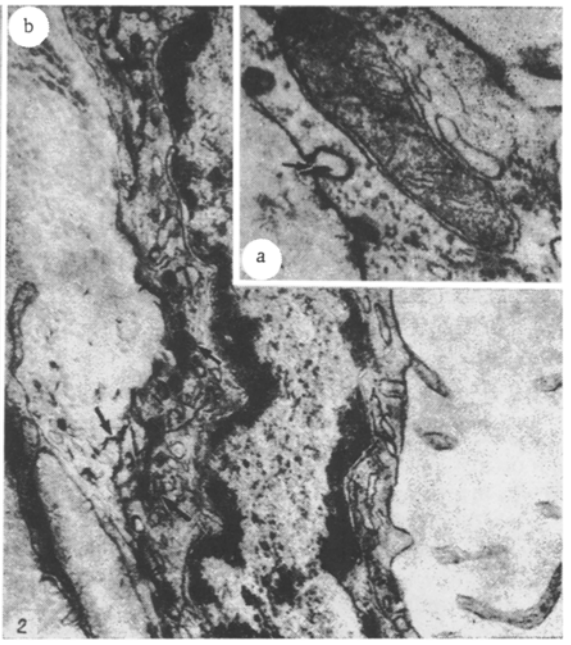

Fig. 2

Fig. 1. Mesothelium of parietal peritoneum 30 min after intraperitoneal injection of 2 ml distilled water: numerous pinocytotic vesicles (arrows) located chiefly in basal part of cell are visible in cytoplasm; 36,500 ×.

Fig. 2. Mesothelium of parietal peritoneum 30 min after intraperitoneal injection of ink suspension: ink particles visible in connective tissue and in pinocytotic vesicles located in basal part of cell (arrows). Magnification: a) 60,000 ×; b) 36,500 ×.

EXPERIMENTAL RESULTS

After injection of the various solutions the response of the mesothelial cells was similar throughout the experiment. In all series of experiments a sharp increase was observed in the number of pinocytotic vesicles (Table 1) located near the plasma membrane in the basal part of the cell (Fig. 1). In the apical part the number of pinocytotic vesicles in the plasma membrane was significantly increased, except in the experiment with the hypertonic solution, but during the first 30 min it was still 1.5-2 times smaller than in the basal part.

Besides the increase in intensity of pinocytosis, some change also was observed in the structure of the nucleus and organoids of the cells. For instance, after injection of the hypotonic and physiological solutions swelling of the mesothelial cells was observed. It was more severe after injection of hypotonic solution, and in the second case only individual cells were affected. After injection of the hypertonic solution cells with degenerative changes appeared, and signs of swelling were absent in the cells which remained intact. No disturbances

in the region of the junction of the mesothelial cells was found in any series. Changes in the underlying connective tissue after injection of hypotonic and physiological solutions were edematous in character and appeared as early as after 5-10 min. Collagen and elastic fibers were enlarged in diameter and were less contrasted than in the control. After injection of hypertonic solution no edema of the connective tissue was found.

Changes in the mesothelial cells after injection of the ink suspension were similar to those found in the experiment with the physiological solution (Table 1). Particles of ink could first be seen in the mesothelium and underlying connective tissue after 20 min. In the mesothelium ink was distributed in the intercellular spaces and in the pinocytotic vesicles (Fig. 2) adjacent to the plasma membrane located in the basal part of the cells, and which bounded the intercellular spaces. Nearly all vesicles in these regions contained ink. Later (30-60 min) ink also appeared in vesicles at some distance from the plasma membrane. Throughout the course of the experiment no ink could be found in vesicles in direct contact with the plasma membrane in the apical part of the cell. Intercellular spaces containing ink were rare, but they were indistinguishable in width from those in the normal mesothelium. Regions where the plasma membranes of neighboring cells and desmosomes were firmly joined together showed no visible changes. Ink could not pass through these zones of contact of the mesothelial cells because of the large size of its particles. The presence of particles in the intercellular spaces closed on the peritoneal side by a tight junction could be explained on the grounds that somewhere in the extent of the contact between that particular cell and the others there was an area that was open on the peritoneal side, through which ink could spread along the intercellular space. Such areas are found under normal conditions also.

Hypotonic and physiological solutions when injected into the peritoneal cavity dilute the serous fluid and change not only its salt composition but also its protein concentration. They penetrate very quickly into the underlying connective tissue, as shown by the swelling of the ground substance observed 5 min after injection. The mesothelial cells play an active role in the absorption of these solutions from the peritoneal cavity. This process is accompanied by swelling of the mesothelial cells and by an increase in their number of pinocytotic vesicles. True solutions evidently pass into the underlying connective tissue by diffusion through the cytoplasm of the mesothelial cells and along the intercellular spaces. The sharp increase in the number of pinocytotic vesicles in all the series of experiments in the plasma membrane in the basal part of the mesothelial cells suggests that they carry tissue fluid by pinocytosis for equalizing the protein and salt composition of the diluted serous transudate. Proof of this hypothesis is given by the experiment in which the ink suspension was injected. Immediately after entering the underlying connective tissue, the ink suspension filled nearly all pinocytotic vesicles near the basal plasma membrane but was absent from the apical part of the cells, although ink was present in the peritoneal cavity almost throughout the experiment. Ink particles in this case penetrated into the pinocytotic vesicles together with tissue fluid. These facts are evidence that the mesothelial cells conduct pinocytosis in a certain direction: from their basal part to their apical part, i.e., they convey tissue fluid into the peritoneal cavity. The absence of edema in the underlying connective tissue after injection of hypertonic solution is explained on the grounds that it was injected in a very small volume (0.2 ml) compared the extensive surface area of the parietal and visceral peritoneum. For this reason the change in composition of the serous transudate was quickly restored without the removal or absorption of a large volume of fluid.

The passage of true solutions (physiological and hypertonic solutions) and of distilled water through the mesothelium and underlying connective tissue thus takes place by diffusion through the cytoplasm of its cells and along the intercellular spaces. Pinocytosis in the mesothelial cells proceeds from their basal to their apical part and is aimed at equalizing the concentration of the protein and salt constituents of the serous fluid.

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