MORPHOLOGY AND PATHOMORPHOLOGY

THE ADSORPTIVE PROPERTIES OF THE TUNICA VAGINALIS PROPRIA OF THE TESTIS

E. B. Khaisman

From the Institute of Normal and Pathological Physiology (Director-Prof. V. N. Chernigovsky, Active Member of the USSR Academy of Medical Sciences), USSR Academy of Medical Sciences, Moscow

(Received December 3, 1956. Presented by Prof. V. N. Chernigovsky, Active Member of the USSR Academy of Medical Sciences)

The processes of adsorption from serous cavities have long interested clinicians, physiologists and morphologists. Cavity resorption of fluid, crystalloids and colloids, suspensions and normal blood elements – all of these have been the subject of experimental studies and clinical observations. Besides their great theoretical interest, their investigation is very important to the needs of practical medicine. Suffice it to say that the development of practical methods of treating a whole series of diseases, which are attended by an accumulation of transudate and exudate, toxins, bacteria, hemorrhaged blood, etc., in the serous cavities, depends a good deal on accurate information as to the absorptive ability of the corresponding serous membranes in normal and pathological conditions. However, the vast majority of the works treating this subject are concerned with the processes of resorption from the peritoneal, pleural and pericardial cavities. The serous cavity of the scrotum and the tunica vaginalis propria of the testis, which lines this cavity, seem to be beyond these researchers' field of vision.

The only works concerning the absorptive properties of the latter membrane were conducted on clinical material and are only incidental, unorganized observations. The authors injected different substances (salts, stains) into the cavity of the mentioned serous membrane under hydrocele conditions, and then, for definite time intervals, traced their appearance in the urine and other excretions. The results of these studies were highly contradictory. According to some authors [6, 7], resorption from the cavity of the hydrocele sac of the tunica vaginalis propria is extremely intense, while, according to others [2, 5, 8], it is slight or entirely lacking. This difference of opinion seems to be explained by the fact that the researchers worked with different forms of testicular tunica vaginalis propria hydroceles, but did not take the histopathological changes in the membrane or the length of the affection into account. It is even more difficult to form a theory from the results of the observations done on the absorption of substances which differed as to diffusion properties and degree of toxicity. They only indicate that functionally and anatomically damaged testicular membranes are permeable by the given substances.

Of course, in order to solve the question we have mentioned, information is needed as to the absorptive properties of the testicular tunica vaginalis propria under normal physiological conditions. However, to date there has been no work in this field. Researchers have not taken advantage of the procedure of extensive research on animals, although this would seem to be an important stage in discovering the rules regulating the different aspects of resorption from the serous cavity of the human scrotum.

According to the literary data, resorption of serous fluid and various substances suspended or dissolved in the serous fluid from the peritoneal, pleural and pericardial cavities is realized by the vascular bed of the corresponding portions of the serous membrane. It has been established that true and high dispersion colloid solutions are absorbed by both the blood and lymph vessels of the serous membrane, but suspensions and low-dispersion colloids by only the lymph vessels [1, 3].

The purpose of this work was to determine the role of the blood and lymph vessels in the resorption of the above substances from the serous cavity of the testicular tunica vaginalis propria.

EXPERIMENTAL METHODS

We used dogs, for the most part, as the experiment subjects. A few cats and rabbits were also used. The experiments were done on healthy, sexually mature males. Three series of experiments were done: 1) on absorption of true solutions; 2) on absorption of colloid solutions and 3) on absorption of suspensions. In the first series, the indicators used to show the resorption course were light green and orange "G", in the second, trypan blue, and in the third, an India ink or Prussian blue suspension. The staining substances were prepared in a physiological solution of sodium chloride. They were injected into the serous cavity of the scrotum in the following way: while the animals were anesthetized, the skin and the underlying layers of the scrotum as far as the testicular tunica vaginalis propria were opened with a small, longitudinal incision; the tunica vaginalis was lightly pulled away and pierced with a hypodermic needle. The stain was injected into the cavity with minimal pressure exerted on the hypodermic plunger. The volume of fluid injected was usually not more than 1-1.5 cc.

Adsorption of the indicators by the blood vessels of the testicular serous membrane was determined by colorimetry of the urine* and of blood plasma from the peripheral bloodstream. In the lymph vessels, the index of resorption was the presence of the stain in the principal lymph capillaries of the tunica vaginalis propria, in the drainage vessels and in the regional lymph nodes.

The experiments lasted from a few minutes to 24 hours. The animals were killed after fixed intervals. The testicles and the covering layers of the tunica vaginalis propria were fixed in formalin for subsequent histological processing of the material. The regional lymph nodes were also examined.

EXPERIMENTAL RESULTS

In the first series of experiments, the crystalloid solutions of the stains injected into the cavity of the dog's testicular tunica vaginalis propria (8 experiments with 1% solution of light green injected and 5 experiments with a 2% solution of orange "G" injected) began to appear in the urine and blood plasma as early as 8-10 minutes after the beginning of the experiment.

When the serous cavity of the scrotum was opened, the following typical picture of indicator distribution along the surface of the testicular tunica vaginalis propria could be seen by the naked eye: intense, diffuse staining of the parietal layer on the one hand, and hardly noticeable traces of stain in the visceral layer on the other (Fig. 1). When the laminar, total preparations of the testicular serous membrane were examined under a microscope, absorption of the stains on the connective tissue structures of the parietal layer and completely selective blood vessel injection of the latter could be clearly seen. Only a slight staining of the fibrous surface laminae could be observed in the visceral layer. When the preparations were processed with solutions of ammoniacal silver (according to Goier), it was established that the mesothelial sheath was adequately preserved in both layers of the testicular tunica vaginalis propria.

After longer experimental intervals (18-20 minutes or more), another phenomenon was added to the just described morphological picture: the outgoing lymph vessels of the parietal layer of the testicular membrane were observed to be injected and the regional lymph nodes (In. medialis) to be stained, becoming increasingly more stained as the experimental interval increased.

Therefore, the results of the experiments injecting true solutions of substances into the cavity of the testicular tunica vaginalis propria showed that true solutions are absorbed by both the blood and lymph vessels located in the stratum of the parietal layers of this serous membrane. However, absorption was more intense in the blood vessel bed, which was indicated by the earlier appearance of the indicators in the peripheral blood and urine than in the outgoing lymph vessels.

In the second series of experiments, a colloid solution of trypan blue (1-2%) was injected into the studied serous cavity. Dogs were used as the experimental subjects. Colorimetric analysis, lasting as long as 4 hours, of

* For this, a fistula was induced in the eviscerated bladder, and then the bladder was replaced into the celiac cavity. The bladder contents were removed at fixed intervals with a micropipette.

negative results in all of the 11 experiments. However, we found the stain in the outgoing lymph vessels of the tunica vaginalis propria parietal layer and in the regional lymph nodes (In. medialis) as early as $1^1/_2$ 2 hours after its injection into the cavity. When the testicular tunica vaginalis propria was exposed, the same phenomenon that appeared in the experiments with crystalloid absorption was observed; i.e., selective absorption, in which, the parietal layer was definitely stained while the visceral layer was almost unchanged in color. When the pellicular preparations were examined under a microscope, it was interesting to observe that, in the parietal layer, the trypan blue was distributed along the edges of the mesothelial cells (Fig. 2). In places, the lymph capillaries were injected with the stain. The light network of canals stood out sharply against the intense blue background of the membrane, showing a "negative" picture of the blood vessels (Fig. 3). In the visceral layer of the testicular serous membrane, one could only find foci of trypan blue distributed along the surface in a few visual fields.

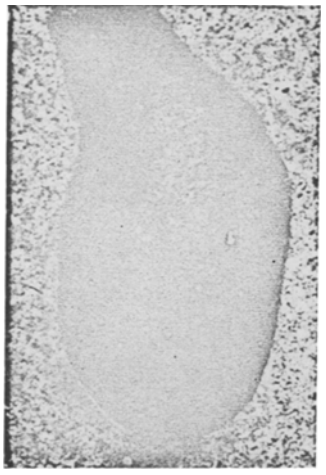

Fig. 1. Tunica vaginalis propria of a dog's testis. 1% solution of light green injected into cavity (experimental interval: 10 minutes). Piece of intensely stained parietal layer sloughed. Visceral layer not stained. Photo. Magnified $1^1/_2$ times in printing.

Fig. 2. Parietal layer of tunica vaginalis propria of a dog's testis. Deposit of trypan blue along the intercellular borders of the mesothelium (duration of experiment: 2 hours). Microphoto. Standard magnification.

Combining the data obtained, we concluded that the chief role in the absorption of colloid solutions (of the trypan blue type) from the testicular tunica vaginalis propria cavity belongs to the lymph vessels in the parietal layer of this membrane. The resorbing function of the blood vessels need hardly be discussed.

In the third series of experiments, 1% suspensions of India ink and Prussian blue were used as the color indicators. A total of 24 experiments were done (10 on dogs, 8 on cats and 6 on rabbits), lasting from a few minutes to 24 hours.

The results of these experiments were identical: in none of the experiments did the suspensions permeate the blood vessel bed of the testicular vaginalis propria, nor did they appear in the lymph vessels or regional lymph nodes draining the studied cavity.

Microscopic analysis of the preparations showed that particles of ink (or Prussian blue) were scattered along the surface of the mesothelium in the visceral layer of the testicular serous membrane. The particles, as a rule, did not penetrate into the underlying layer. In the parietal layer, the suspended particles were mainly distributed along the intercellular borders of the mesothelium. Single granules were found in the cytoplasm of the mesothelial cells. After long experimental intervals (12-24 hours), many histiocytes, phagocytizing the color particles (Fig. 4), were found among the fibrous structures of the parietal layer.

From the data presented above, it is evident that the testicular tunica vaginalis propria and its vascular bed do not directly participate in the resorption of suspensions. This membrane, therefore, is essentially different from

other serous membranes. Corpuscular particles are known to be removed from the peritoneal cavity, the pleural cavity and the pericardial cavity by means of the lymph system. In definite zones of the corresponding membranes, the intraserous lymph vessels are in close contact with the corresponding cavities,* due to the features of the histological structure of the membranes. The resorption of fluids and particles suspended in fluids is provided for in the same way.

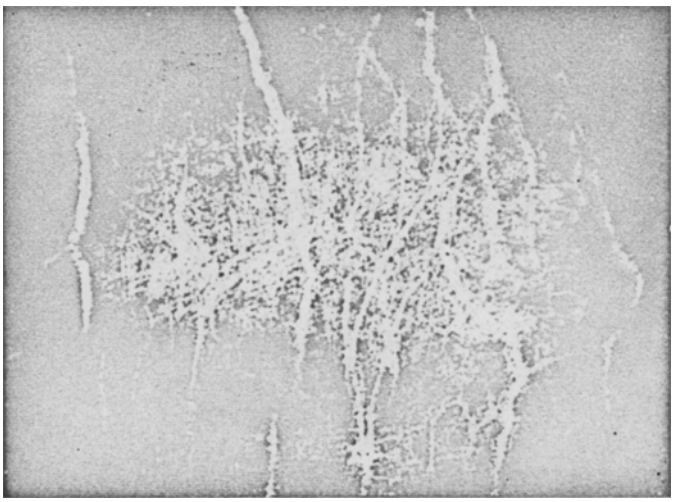

Fig. 3. Parietal layer of tunica vaginalis propria of a dog's testis (explanation in text). Microphoto. Standard magnification.

Such relations were not observed in the scrotal serous membrane of the animals we examined. As a rule, the lymph vessels draining that cavity are located in the deep layers of the testicular peritoneal sheath and are separated from its surface by a thick, fibrous wall.

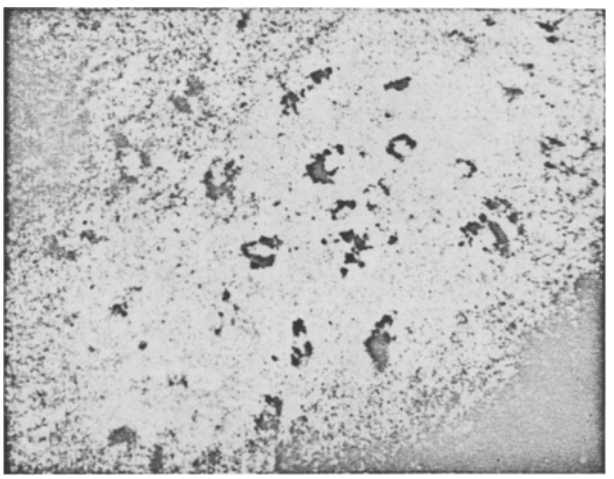

Fig. 4. Parietal layer of tunica vaginalis propria of a dog's testis. Accumulation of India ink granules in histiocytes (experimental interval: 24 hours). Microphoto. Standard magnification.

* It is a question of the peculiar communication system in the surface layers of the membranes (stomata in in the mesothelium, "windows" of the marginal membrane and openings in the loops of the fibrous network), which are known in the literature as "hatches".

What happens to the various cellular elements (which constitute the mesothelial cells, the blood corpuscles, etc.) and their decomposition products, which are always present in the cavity of the testicular tunica vaginalis propria? There are two important facts which can be helpful in solving this problem: first, that, in the majority of mammals,* this cavity is connected with the peritoneal cavity by the uncovered processus vaginalis peritonei, and therefore, ways exist for the transfer of fluid and suspended particles from the serous cavity of the scrotum into the peritoneal cavity; and second, that the transfer of suspensions absorbed by the surface of the tunica vaginalis propria into the drainage system is possible by means of macrophage elements.

SUMMARY

Absorptive properties of the testicular tunica vaginalis propria are distinctly manifested only in case of true and colloidal solutions. Morphological experiments have clearly demonstrated that crystalloids are absorbed both by blood and lymphatic vessels of this serous membrane, while colloids only by its lymphatic vessels. In both cases the outstanding role is that of the vascular bed of the parietal sheath. The ability of the tunica vaginalis propria to resorb suspensions is insignificant or even nil.

LITERATURE CITED

[1] M. A. Baron, in the book: Works of the 1st Moscow Medical Institute,** Moscow, 1936, pp. 281-291.

[2] G. I. Goldin, Urologiya, 1930, Vol. 7, No. 4, pp. 161-170.

[3] D. A. Zhdanov, The General Anatomy and Physiology of the Lymph System,** Leningrad, 1952.

[4] A. P. Krymov, The Peritoneal-Inguinal Process and Its Pathological Importance,** Dissertation, Moscow, 1906.

[5] G. M. Curtis and A. Brunschwig, Proc. Soc. Exper. Biol. a. Med., 1930, Vol. 27, N. 5, pp. 358-360.

[6] T. Kochen, Krankheiten d. mannlichen Geschlechtsorgane, Auttgart, 1887.

[7] K. Wederhake, Ztbl. f. Chir., 1937, N. 37, S. 838-841.

[8] L. Torraca, Arch. Ital. di Chir., 1922, Vol. 6, pp. 404-420.

* Only in man, manlike apes and in some kinds of marsupials is the cavity of the testicular tunica vaginalis propria closed due to the obliteration of the processus vaginalis peritonei [4].

** In Russian.