INNERVATION OF AN ARTIFICIAL ADHESION BETWEEN THE SMALL INTESTINE AND HEART

(UDC 616.341-089.843-031:611.12]612.83)

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 61, No. 2, pp. 105-109, February, 1966
Original article submitted August 10, 1964

During recent years in experimental surgery, considerable attention has been paid to the problem of the revascularization and transplantation of organisms. In this conncection, investigations of the process of adhesion formation between various tissues and organs are of great interest. The author, when working on the problem of revascularization of the myocardium, studied the possibility of using the small intestine to increase the blood supply to the myocardium in pathological conditions.

EXPERIMENTAL METHOD

Jejunocardiopexy was performed through a transthoracic route on adult dogs of both sexes under general anesthesia. The object of the operation was to form an artificial adhesion carrying blood vessels between the organs. Experiments lasted for periods of between two weeks and eight months. Altogether 18 preparations of the adhesion between the organs were investigated. The material was fixed in 12% neutral formalin solution. Sections were cut on a freezing microtome to a thickness of 15-60 μ and stained by the Bielschowsky-Gros method.

EXPERIMENTAL RESULTS

Two weeks after the operation, the adhesion between the heart and small intestine consisted of young connective tissue with large numbers of tiny newly formed blood vessels, ramifying to form a network. No elements of nerve tissue could be found. In some areas of the subepicardial plexus, fibers with signs of degeneration could be seen (irregularity of staining, bead-formation, appearance of granules and masses of pigment, and so on). In the intermuscular nerve plexus of the intestine, degenerative changes were observed only in cases when an operation or severe injury was done to the outer layer of the muscular coat.

One month after suturing the intestine to the heart, the adhesion between the organs was more mature. In this case, many cells were seen and the fibers in the ground substance were collected into bundles and lay parallel to the plane of connection of the organs. During further differentiation of the tissues of the adhesion, the elements of the intercellular substance began to be more numerous than the cells. The blood vessels were numerous and formed a network of wide loops. No nerve fibers could be seen at this period.

Nerve elements in the adhesion were first observed two months after its formation. Individual nerve fibers penetrating the connective tissue at this period from one organ to the other may be seen in Fig. 1. The thickness of these fibers did not exceed 4-5 μ, and they were feebly impregnated with silver salts; in their course, they gradually became thinner and were lost in the connective tissue. These fibers resembled the "transit" fibers described by V. N. Blyumkin [2]. Usually they did not form typical nerve endings, but showed only bulbs of growth, and they passed transversely through the whole thickness of the adhesion from one organ to the other. Likewise, no afferent endings could be observed at this period, although at some places a fan-shaped divergence of fibrils could be seen, somewhat resembling the initial stage of formation of receptors. Since nerve fibers were found for the first time in the immediate vicinity of the epicardium, there is reason to suppose that they originated from the subepicardial plexus.

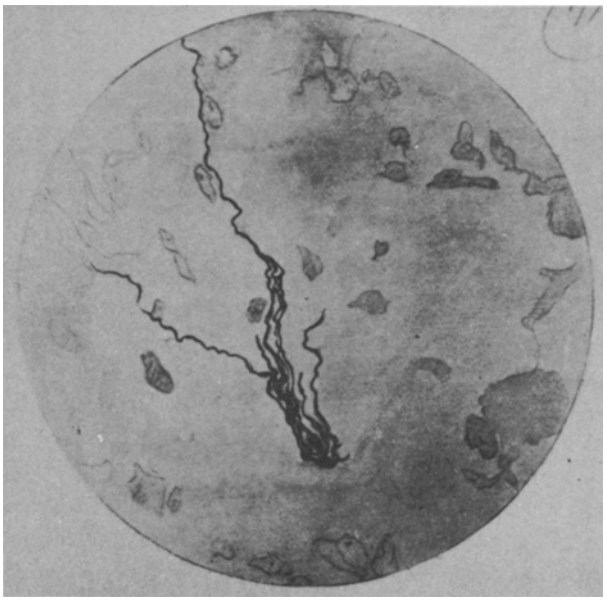

Fig. 1. Thin nerve fibers in connective tissue of adhesion between organs (two months after operation). Impregnation by Bielschowsky-Gros method. Objective 90 (immersion), ocular 15.

Fig. 2. Mixed nerve fibers with characteristic tortuosity (six months after operation) in connective-tissue adhesion. Impregnation by Bielschowsky-Gros method. Objective 40, ocular 15.

Four months after jejunocardiopexy, the innervation of the connective-tissue adhesion still remained scanty. In most cases, the nerve fibers were combined into thin bundles, but solitary fibers were still found. They varied in thickness. They evidently included both medullated and nonmedullated fibers. In some cases, comparatively thick trunks could be seen, bending in zigzag fashion along their course; they gave off branches which came into contact with the wall of the newly formed blood vessels. This period was characterized by the disappearance of signs of degeneration from the subepicardial plexus.

Starting with six months after the operation, numerous nerve fibers of different diameters, running in different directions, could be seen in the connective tissue of the adhesion between the organs. Besides solitary fibers, trunks of different thickness could be seen, consisting of mixed fibers of medullated and nonmedullated types (Fig. 2).

The innervation of the adhesion between the heart and intestine evidently developed from the subepicardial plexus, for growth of the nerve fibers took place from the epicardium towards the intestinal wall.

Eight months after the operation, a well marked network of wide loops of nerve fibers could be seen throughout the extent of the adhesion between the organs. Anastomoses were present between the branches of the nerve trunks. The fibers varied in thickness, some were medullated and others nonmedullated. The fibers were arranged transversely in the adhesion and were very characteristic in appearance; throughout their course they ran in zigzag fashion, they were bent in places, and sometimes they made a complete turn (Fig. 3). These morphological peculiarities correspond to the special conditions created in an adhesion between organs, continually subjected to stresses during the cardiac contractions. The zigzag and spiral course of the nerve fibers is also seen in adhesions of other organs subjected to distention or displacement, as demonstrated by V. S. Bazhenov and V. N. Blyumkin [1] in intrapleural adhesions in pulmonary tuberculosis.

In the same preparations, differences in the intensity of impregnation of the nerve fibers with silver salts were frequently observed, as reported earlier by Nonidez [8] and others. Many investigators [5-8] consider that the variation in the degree of impregnation of the nerve fibers depends on their origin. It has been observed, for instance, that fibers of the sympathetic nerves are feebly impregnated with silver nitrate, appearing pale yellow or brown in color, whereas the parasympathetic and somatic fibers stain an intensive brown color or even black.

This sign may to some extent be used to determine the nature of nerve fibers.

At these periods of the experiments, receptor endings were clearly observed in the adhesion between the organs near the blood vessels. Usually they were arranged longitudinally and had the appearance of separate twigs, brushes, or small loops.

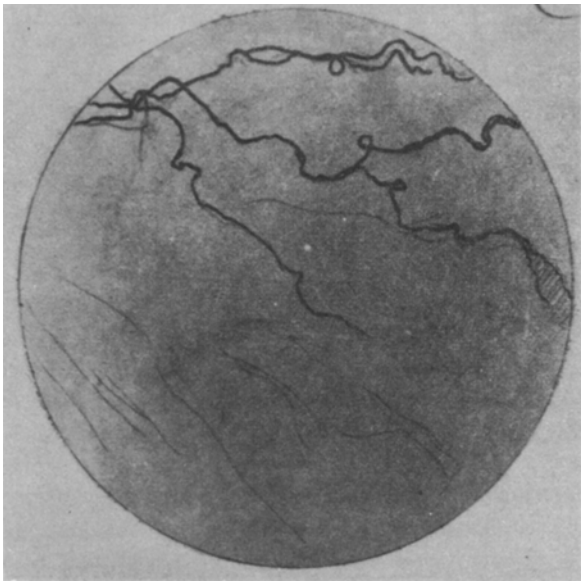

Fig. 3. Bundles of nerve fibers running from the epicardium towards the intestinal wall in an adhesion between the organs (eight months after operation). Characteristic turns can be seen in some fibers. Impregnation by Bielschowsky-Gros method. Objective 40, ocular 10.

No convincing data could be obtained showing the presence of nerve cells in the adhesions. However, in some cases, structures resembling nerve cells were observed.

Structurally they were large cells containing a light nucleus, surrounded by cytoplasm, giving off processes of different thickness and length. In the early periods of the experiments, no structures of this type were seen. However, this question requires further study.

The results show that the innervation of adhesions between the heart and intestine becomes visible two months after operation. Subsequently, the development of the nerve element is intensified; a ramified network of nerve fibers of different origin is formed, with receptor fields and a number of free endings. There is reason to suppose that the nerve elements of the adhesion between the organs develop mainly on the subepicardial plexus whereas the intermuscular nerve plexuses of the intestinal wall play only a small part in this process. In this respect, these findings differ somewhat from those reported by V. N. Blyumkin [2,3], who saw a mutual exchange of nerve fibers between the abdominal viscera.

Finally, Sh. G. Gordeziani [4], who investigated an adhesion between the heart and the greater omentum of a dog, found that nerve fibers spread from the sutured omentum into the membranes of the heart. Evidently, this question has not been finally settled.

Hence, from six to eight months after the operation, an artificial connective-tissue adhesion, formed between the heart and intestine of the dog, acquired a nerve supply. Even in the early periods, a close contact was seen between the nerve elements and the uniform blood vessels. Afferent endings appeared rather later.

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