

MORPHOLOGY OF EXPERIMENTAL MYOCARDIAL INFARCTION TREATED BY VARIOUS SURGICAL METHODS

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A myocardial infarct was produced in dogs by ligation of the coronary artery. Fiesca's operation performed beforehand or at the same time had no favorable effect on the course of the disease. Conversely, the operation of pericardiocardiopexy and omentocardiopexy, while not preventing the development of a myocardial infarct, improved its clinical picture and this was associated with correspondingly less severe morphological changes.

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Experimental and clinical investigations have shown that attempts to treat coronary disease by surgical methods are justified, although many aspects of this problem remain unexplained [2, 4, 9].

The object of the present investigation was to study morphological characteristics of myocardial infarction when treated by various methods.

EXPERIMENTAL METHOD

Experiments were performed on 119 dogs (6 series). The number of animals, the types of operations, and the periods of investigation are shown in Table 1. A myocardial infarct was produced by ligation of the anterior branch of the left coronary artery in its upper third. The effectiveness of the operation was assessed from the survival of the animals, dynamics of the electrocardiogram (ECG), changes in activity of the serum transaminases, and by angioradiography. The heart was fixed in formalin and acetone and sections cut from various parts were stained with hematoxylin-eosin and picrofuchsin. Some sections were also investigated histochemically (Brachet's and Feulgen's reactions, PAS, toluidine blue). In 11 cases succinate dehydrogenase activity was determined with nitroblue-tetrazolium.

EXPERIMENTAL RESULTS

Analysis of the experimental results reveals considerable similarity in the clinical picture of myocardial infarction in the animals of the first three series. As Table 1 shows, mortality among the animals undergoing Fiesca's operations was approximately the same as in the controls. The operations of omentocardiopexy and pericardiocardiopexy considerably altered the course of the myocardial infarct. The dogs did not develop ventricular fibrillation and no deaths took place during the first day of the experiment. Electrocardiographic signs of infarction developed slowly and were not so marked as in the animals of the first three series. More favorable changes in the dogs undergoing the operations were also observed in the transaminase level. Whereas the infarcts in the dogs of the first three series as a rule were transmural, in the animals of series IV-V they were small in size and localized mainly subendocardially or subepicardially.

During ventricular fibrillation, which varied in duration, circulatory disturbances were observed in the heart (congestion, stasis, hemorrhage, edema of the stroma), sometimes with eosinophilia of the muscle fibers and foci of cloudy swelling.

The morphology of the myocardial infarct in the animals of the control group was similar to that in dogs undergoing Fiesca's operation. In the first three days of the experiment circulatory disorders, degeneration and necrosis of muscle fibers, and a leukocyte response were observed. With increasing length

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TABLE 1. Distribution of Experimental Animals by Type of Operation and Periods of Investigation

	Type of operation	Num- ber of dogs	No. dying		No. surviving and sacrificed after						
			from fibril- lation	from in- farction	1-24 days	2-3 days	4-7 days	8-15 days	16-30 days	1-3 months	over three months
I	Ligation of coronary artery	16(18)	5(1)	3(1)	1(13)	—	(3)	2	3	1	1
II	Ligation of coronary artery simultaneously with Fiesca's operation	15	4	2	—	—	1	—	3	3	2
III	Ligation of coronary artery three weeks after Fiesca's operation	17	4	3	—	—	—	—	3	6	1
IV	Ligation of coronary artery three weeks after operation of pericardiocardiopexy	13(9)	—	3	(4)	(2)	(2)	1	4(1)	3	2
V	Ligation of coronary artery three weeks after operation of omentocardiopexy	13(4)	—	3	(3)	—	2(1)	1	3	4	—
VI	Ligation of coronary artery with measurement of reflux blood flow (acute experiment)	14	4	—	10	—	—	—	—	—	—
	Total.....	88(31)	17(1)	14(1)	11(20)	(2)	3(6)	4	16(1)	17	6

Note. Numbers without parentheses denote number of animals whose heart was investigated by ordinary histological methods, numbers in parentheses denote number investigated by histochemical methods.

of the experiment the infarct underwent organization, and after one month a fibrous scar had formed in its place, sometimes containing fatty tissues.

After the operation of pericardiocardiopexy, fibrous adhesions containing residual talc particles and foreign body giant cells developed between the epicardium and pericardium. The infarcts in the heart of the sacrificed dogs were small in size, and left behind them scars consisting of collagen fibers, cells (fibroblasts, fibrocytes, histiocytes), with bundles of intact muscle fibers.

In the animals previously undergoing omentocardiopexy, varied changes were found in the heart. In two of the three dogs dying on the second day, no typical changes characteristic of myocardial infarction were found in the myocardium. Small single or confluent foci of myolysis and cloudy swelling of muscle fibers with a histiocyte response in the stroma were found in these animals subendocardially (Fig. 1), and in the surviving dogs these changes were intensified on the 4th-7th day of the experiment. In one dog foci of myolysis were found against a background of myocardial infarction. In the latter periods of investigation, many intact muscle fibers were found in the small scars. In every case, outside the infarct at late periods of observation, arteries of the shunt type were formed with proliferation of connective tissue, and sometimes of fatty tissue, around them.

Disappearance of glycogen in every case preceded the appearance of PAS-positive material and necrosis of muscle fibers. Mainly a focal disappearance of glycogen was observed in the myocardium of dogs after cardiopexy, whereas in the control animals glycogen disappeared over an extensive area (Fig. 2). In some animals undergoing the operation, the glycogen content in the myocardium outside the zone of the infarct was somewhat greater than in animals not undergoing the operation. An increased intensity of staining of formazan granules with changes in their size and shape were observed 24 h after ligation of the coronary artery (the heart was not investigated sooner), and they coincided topographically with areas of glycogen disappearance (Fig. 3). Distribution of acid and neutral mucopolysaccharides and nucleoproteins

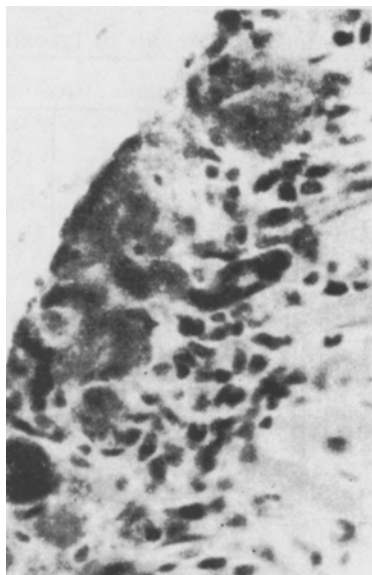


Fig. 1. Photomicrograph. Focus of myolysis and cloudy swelling of muscle fibers in endocardium with histiocyte response. Hematoxylin-eosin, 200 \times .

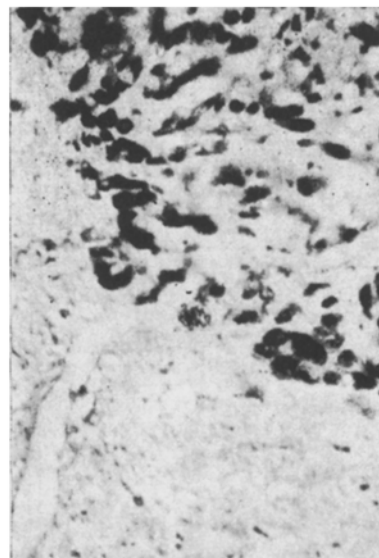


Fig. 2. Photomicrograph. Total disappearance of glycogen from zone of ischemia (below) and partial disappearance in border region (above). PAS reaction, 60 \times .

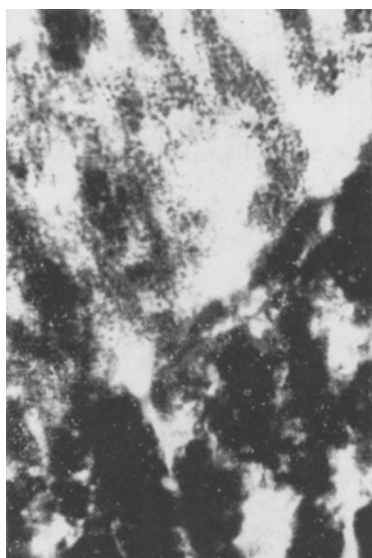


Fig. 3. Photomicrograph. Intensified staining of formazan granules, increase in their size, and fusion to form large granules in the area of ischemia (above). Reaction for succinate dehydrogenase, 60 \times .

in the zone of ischemia and infarction in the animals of the different series of experiments showed no qualitative differences.

The study of the dogs' hearts after ligation of the coronary artery against the background of certain operative procedures thus showed that, although pericardiocardiopexy and omentocardiopexy do not prevent the development of a myocardial infarct, they considerably modify its clinical course and morphological picture. Fiesca's operation had no effect on the course of myocardial infarction.

In our experiments we were unable to confirm published data [8] indicating that ventricular fibrillation is characterized by a definite topography of its morphological pictures in the form of vascular disturbances and necrobiosis of muscle fibers. The changes described evidently are characteristic of sudden death of the animals against the background of myocardial ischemia. It is an interesting fact that in 11 of the 15 dogs undergoing angioradiography, the territory of distribution of the ligated artery was empty, whereas in other animals a reflux blood flow was present in the zone of ischemia (experiments of series VI). In other words, mainly those animals in which insufficient anastomoses and collaterals were present in the myocardium died from ventricular fibrillation.

The morphology of the myocardial infarct in the control animals and in the dogs undergoing Fiesca's operation was indistinguishable from that described previously [1, 5, 7]. The study of the morphological picture of the heart in dogs previously undergoing organopexy operations is interesting. The protective role of these operations is that they create an additional inflow of blood into the myocardium [9]. Probably the vessels of the myocardium itself, which undergo considerable reorganization, play a major role in this process. A combination of these and other factors have the result that small infarcts develop in the heart of the dogs after these operations, sometimes accompanied

by foci of myolysis and a histocyte response. These results may be classified along with the myocardial injuries [3] of focal character which can be caused by hypoxia of angiogenic type [6].

It has been reported in the literature that organocardiopexy operations lead to more rapid healing of the infarct [2, 4]. It must be concluded from the results of our experiments that these operations lead to the more rapid formation of collagen fibers, but formation of a dense scar takes longer.

The results of the histochemical investigations do not conflict with previous data [1, 5, 7]. One fact should be noticed which calls for clarification: in the myocardium of dogs undergoing omentocardiopexy, formazan granules outside the infarct were dark brown in color in all areas of the heart, whereas in the other animals they were dark blue in color. Organocardiopexy operations evidently modify metabolic processes in the myocardium, but a special study of this question is needed.

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