

## FAT EMBOLISM OF THE THEBESIAN VESSELS\*

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Mechanical trauma is often followed by fat embolism. I. V. Davydovskii [4], for instance, states that an "aclinical" form of fat embolism is an almost constant background of any injury, whether a surgical operation or a war wound.

In fat embolism considerable lesions of the heart are often present. These may be revealed, in particular, by the electrocardiographic changes observed in fat embolism, the origin of which is associated by some authorities [13] with reflex spasm of the coronary arteries. The brilliant research of S. A. Vinogradov [3] has confirmed the fact that there is oxygen lack in the myocardium in fat embolism. These changes in the myocardium may be associated with disturbance of the coronary blood flow. Nevertheless, in the accessible literature we found no information regarding the role of the Thebesian vessels in trauma or the possibility of fat embolism of these vessels.

In the present investigation our aim was to reproduce experimentally the entry of fat and ink from the right ventricle of the heart into the myocardium along the Thebesian vessels.

Experiments were carried out on ten dogs, weighing from 9.5 to 24 kg. In order to reproduce embolism we used fat and Chinese ink. The animals were anesthetized with morphine and urethane, and an artificial respiration machine was used in the experiments. A cannula with a rubber tube leading to a flask was inserted into the left pulmonary artery. The right pulmonary artery was ligated. This was necessary in order to exclude the lesser circulation and to prevent any possibility of the passage of emboli through the orifice of the coronary arteries and the left ventricular vessels of Thebesius. Variants of this method were widely used in the well-known investigations of Pratt [12], Wiggers [15], and other authors. We injected either sunflower oil, heated to 38°, or Chinese ink, diluted with Lokce's solution, into the external jugular vein. The duration of contraction of the heart from the beginning to the injection of sunflower oil and Chinese ink was from 20 seconds to 7 minutes (the experiments were conducted in the Department of Normal Physiology). The dogs' hearts were removed from the thorax and fixed in a 10-15% solution of formalin. The weight of the heart, when full of oil or ink, varied from 180 to 300 g. The thickness of the wall of the right ventricle was 3-7 mm, and that of the left – 14-17 mm. Numerous orifices of the Thebesian vessels were found in the endocardium on the left and right ventricles. From the hearts, 33 pieces were excised for histological examination, in the endocardium of which Thebesian vessels were found. In this way we investigated areas of the efferent and afferent tracts, the region of the apex and the interventricular septum of the right ventricle. Several pieces of heart tissue were taken from the left ventricle. In this way serial sections were prepared for histological investigation. The sections were stained with hematoxylin, eosin, picrofuchsin, elastin and Sudan III.

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Fig. 1. Ink in the region of the orifice of a right ventricular Thebesian vessel. Ocular 7x, objective 20x. Stained with hematoxylin and eosin.

## RESULTS

The experimental results are given in the Table, from which it can be seen that some relationship exists between the depth of penetration of the emboli along the right ventricular Thebesian vessels and the duration and strength of the contraction of the heart. In experiment No. 6, for instance, with weak cardiac contractions lasting 20 seconds, no emboli were found in the right ventricular Thebesian vessels. In experiments Nos. 1 and 2, with cardiac contractions lasting 30 seconds, emboli were found only in the region of the orifices and in the subendocardial sinusoids. In experiment No. 5, with energetic contractions of the heart lasting 4 minutes after the beginning of the experiment, emboli were found in the Thebesian vessels in the whole thickness of the right ventricular myocardium and in the right ventricular capillaries, arteries, arterioles and veins.

On microscopic investigation hemorrhagic foci and areas of fragmentation in the form of numerous transverse ruptures of the myocardium, affecting from two to eight muscle fibers, were found. The edges of the tears were uneven and displaced. In some sections Thebesian vessels were found opening out on to the endocardium of the centricules. According to work done in the Department and to our personal observations, the Thebesian vessels of the right ventricle are constructed in the manner of sinusoids. The latter were lined with endothelium, situated on a fine, barely perceptible underlying layer of elastic and collagen fibers. In the lumen of the right ventricular sinusoids were found erythrocytes, fat droplets and ink. We found both fat and ink in the region of the orifices of the sinusoids, in the subendocardial and more deeply situated sinusoids, and also in the arteries and veins of the myocardium (Fig. 1).

The histological sections thus gave evidence of the presence of emboli not only in the orifices of the Thebesian vessels, but also in their deep branches and also in the arteries and veins of the myocardium.

It must be pointed out that there is a vast literature on the subject of embolism of the vessels of the heart. In particular, the vascular disturbances of the myocardium in cases of coronary embolism have been widely discussed in the classical textbooks and in articles in the current journals [10]. Nevertheless, in the accessible literature we found no description of embolism of the Thebesian vessels.

Our experiments to reproduce embolism of the Thebesian vessels of the right ventricle may widen our ideas of the circulation of the blood in the myocardium itself.

The experiments have demonstrated the possibility of access of blood from the right ventricle into the thickness of the myocardium. We account for embolism of the arteries and veins by the presence of anastomoses between the Thebesian vessels and the arteries and veins of the myocardium, which have been described by several authors [5, 6, 8, 11, 14].

Relationship between Depth of Penetration of Emboli and Strength of Cardiac Contractions

Experiment No.	Weight of dog (in kg)	Sex	Volume of oil in- jected (in ml)	Volume of ink in- jected (in ml)	Duration of injection of oil or ink	Duration of cardiac contrac- tion from begin- ning of injection	Localization of emboli in Thebe- sian vessels of ventricles				Localization of emboli in arteries, veins and capillaries of the ventricles of the heart		Remarks
							orifice	right		left			
									subendo- cardial	deep	subendo- cardial	deep	
1	19	♂	28 sec	20	30 sec	30 sec	+	+	+	+	+	+	Weak cardiac contractions
2	21	♂	28 sec	60	30 sec	30 sec	+	+	+	+	+	+	Energetic cardiac contractions
3	15	♀	30 sec	40	1 min	4 min 16 sec	-	-	-	-	+	+	Weak cardiac contractions
4	9,5	♂	3 min 51 sec	70			+	+	+	+	+	+	Energetic cardiac contraction. After 5-6 contractions of the heart the branch of the left pulmonary artery was clamped for the duration of 3-4 cardiac contractions
5	14	♂	4 min	150	4 min	4 min	-	-	-	-	+	+	Energetic cardiac contractions
6	24	♀	20 sec	20	20 sec	20 sec	-	-	-	-	-	-	Weak cardiac contractions
7	20	♂	1 min 2 sec	70	1 min 2 sec	1 min 17 sec	-	-	-	-	+	+	Energetic cardiac contractions
8	18	♂	1 min 44 sec	100	1 min 44 sec	2 min 44 sec	-	-	-	-	+	+	Energetic cardiac contractions
9	11,2	♂	3 min	100	3 min	4 min	-	-	-	-	+	+	Energetic cardiac contractions
10	13,5	♂	5 min	84	5 min	5 min	+	+	+	+	+	+	Energetic cardiac contraction. After 5-6 contractions of the heart the branch of the left pulmonary artery was clamped for the duration of 3-4 cardiac contractions

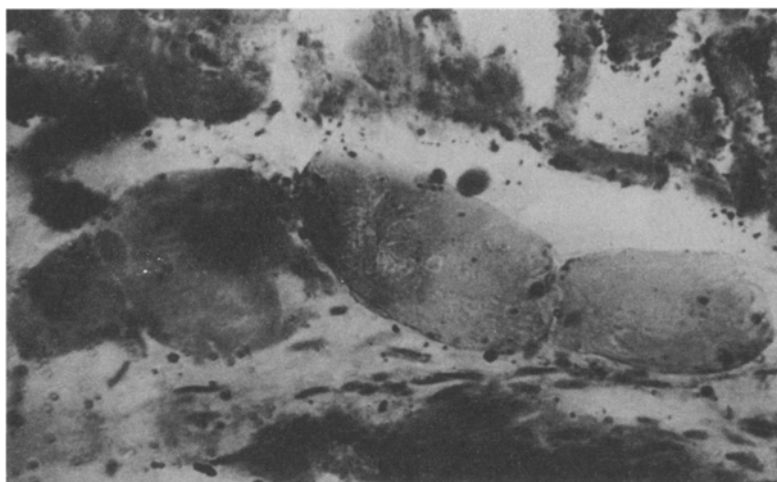


Fig. 2. Fat emboli in the lumen of the right ventricular Thebesian vessels. Ocular 15 $\times$ , objective 8 $\times$ . Stained with Sudan III.

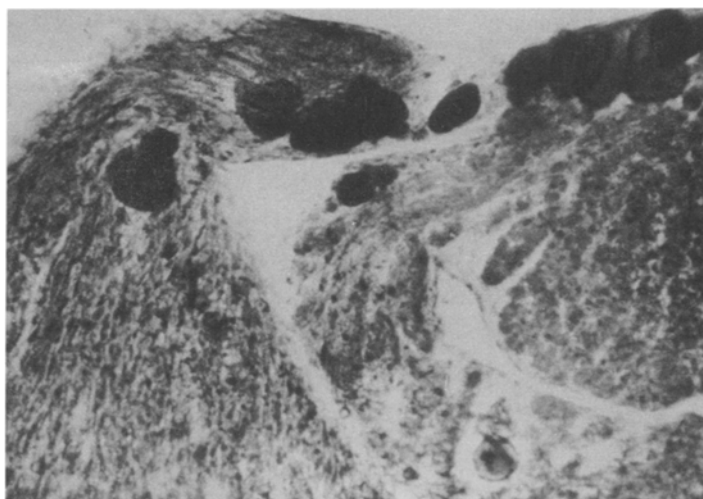


Fig. 3. In the region of the orifice and the subendocardial ramification of a right ventricular Thebesian vessel there are fat droplets. Ocular 6 $\times$ , objective 7 $\times$ . Stained with Sudan III.

We therefore consider that the hemorrhagic foci and the areas of fragmentation of the myocardium may be associated with embolism of the branches of the coronary system, which the emboli reach along the Thebesian vessels of the right ventricle.

A similar possibility of fat embolism may occur in clinical practice in cases of trauma.

We have made detailed studies of two cases of death from acute trauma in which we found fat embolism of the Thebesian vessels of the right ventricle in human subjects (Figs. 2 and 3).

In both the experiments and the cases of trauma in man, with fat embolism of the Thebesian vessels of the right ventricle we observed foci of dystrophy and necrosis of the myocardium. These changes are in agreement with the descriptions given by various authors working on the subject of fat embolism. In particular, I. V. Davydovskii [4] states that cardiac failure occupies an important place as a cause of death in fat embolism.

Functional changes in the heart in fat embolism have been recorded by clinicians by means of electro-

cardiography. The morphological changes under these same circumstances consist of hemorrhages beneath the endocardium along the course of the conducting system of the heart, and of fatty dystrophy of the muscle fibers [7]. In cases of fat embolism, S. A. Vinogradov [3] describes interstitial and perivascular edema, disappearance of the cross-striation of the muscle fibers, breaking up of their protoplasm into clumps, and small and extensive foci of necrosis. Side by side with these changes, a cellular reaction and sclerosis of the stroma were seen.

The pathogenesis of the changes described in the heart in fat embolism has been interpreted in various ways. Scherf and Schönbrunner [13] and others, for instance, explain them by reflex spasm of the coronary arteries. S. A. Vinogradov [3] associates the changes in the myocardium with discoordination between the work of the heart and its oxygen supply. A. I. Abrikosov [1], K. D. Éristavi [9] and others believe it possible that a direct obstruction of the branches of the coronary vessels with fat emboli lies at the basis of the changes in the myocardium.

From our point of view, in the interpretation of the microscopic changes in the myocardium associated with general trauma, it is essential to take account of the possibility of fat embolism of the coronary vessels of the heart and of the system of the Thebesian vessels.

#### SUMMARY

Embolism of the right ventricular Thebesian vessels was induced with fat and China ink in experiments on 10 dogs with the pulmonary circulation excluded. Thebesian vessels of the right ventricle were investigated in 2 patients, dying of trauma. Microscopic investigation of cardiac tissues in experimental and clinical conditions has demonstrated the presence of emboli in Thebesian vessels throughout the whole myocardium of the right ventricle, its capillaries, arteries, arterioles, and veins. These data point to the possibility of the blood from the right ventricle to enter the myocardium. One may, therefore, associate the presence of hemorrhagic foci and areas of myocardial fragmentation with embolism of the branches of the coronary system, where the emboli pass through the Thebesian vessels of the right ventricle.

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