THE EFFECT OF LONG-STANDING EXPERIMENTAL ARTERIOVENOUS ANEURYSMS ON THE HEART

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The influence of arteriovenous aneurysms on the central and peripheral circulation has been the subject of a considerable number of monographs and papers. This fact demonstrates the unfailing interest of workers in various countries in this field of pathology. There are several experimental investigations [4-8 and others] which supplement the findings of clinical observations. However, certain features of the complex pathogenesis of the cardiovascular disturbances arising with arteriovenous aneurysms still remain unexplained; in particular the mechanism of development of bacterial endocarditis and endarteritis in the fistula. In the world literature only a few papers have been published on the experimental production of endocarditis in these conditions [10-12].

In the present investigation we set out to study the effect of arteriovenous fistulae on the heart in experiments of long duration (up to one-and-a-half years) using a combined method of investigation. This consisted of radiography of the heart, electrocardiography, determination of the rate of the cardiac rhythm, and pathological-anatomical and histological study of animals dying or killed at different times; other investigations included temperature recording, blood cultures and measurement of the ESR. This method (combined investigation) enables the progress of the changes in the heart of the experimental animals to be observed more fully and comprehensively.

EXPERIMENTAL METHOD

The experiments were performed on 20 dogs weighing 15-20 kg. Arteriovenous fistulae were produced aseptically in the femoral vessels; in 4 animals an anastomosis was produced between the abdominal aorta and the inferior vena cava. The femoral fistulae were produced as a rule in both limbs with an interval of from 2 weeks to 2 months between the operations.

In order to expose the femoral vessels the superficial tissues were divided along the line of the femoral artery. Access to the abdominal aorta and inferior vena cava was secured by a midline incision in the anterior abdominal wall. The loops of bowel were partly displaced upwards and partly evverted onto a sterile towel thoroughly soaked in warm physiological saline. Linear incisions along the course of the arterial and venous trunks were made easily by the use of an instrument specially made for the purpose—a "vascular probe." This consists of an elongated cone with a pointed apex, on the surface of which a narrow longitudinal groove is made. With a continuous suture the medial border of the incisions in the artery and vein is first sutured, and then the lateral. Altogether 35 functioning arteriovenous fistulae, 1-3 cm in diameter, were produced.
X-rays of the chest were taken in the frontal plane with a portable RU-760 x-ray apparatus, with the heart in the same position relative to the tube of the apparatus. Films were taken before operation, immediately after operation, and then regularly every 10-20 days.

The electrocardiograms were always recorded under the same conditions, in the standing position (in a frame). The action currents of the heart were recorded by 3 standard leads from the limbs by an EKP-4 apparatus with a constant sensitivity of 1 mv = 10 mm. The initial electrocardiographic baseline was established after the total extinction of reflexes to the environment [9]. After the fistula was created, the first electrocardiogram was taken not immediately but after a few days. This avoided abnormalities caused by incidental factors (anesthesia, pain, changes in the position of the body and so on). Subsequent recordings were made periodically, at the same intervals as the x-rays. In the whole combined investigation about 150 x-rays and over 100 electrocardiograms were taken, processed and analyzed.

**EXPERIMENTAL RESULTS**

At any time of the existence of arteriovenous aneurysms (Fig. 1) the characteristic sound could be heard on auscultation on the site of a fistula — continuous, low pitched, with intensification and raising of the tone during systole; a sensation of fibrillation on palpation corresponded to the bruit. In the femoral anastomoses we observed the rapid development of venous collaterals.

![Fig. 1. Experimental arteriovenous aneurysm of the femoral vessels.](image)

<table>
<thead>
<tr>
<th>Size of fistula in cm</th>
<th>Pulse before creation of fistula</th>
<th>Pulse after creation of fistula</th>
<th>Degree of pulse quickening (beats/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>84</td>
<td>102</td>
<td>18</td>
</tr>
<tr>
<td>2.0</td>
<td>95</td>
<td>118</td>
<td>23</td>
</tr>
<tr>
<td>2.5</td>
<td>107</td>
<td>140</td>
<td>33</td>
</tr>
</tbody>
</table>

Ligation of the fistula did not cause any noticeable alteration in the size of the heart, which suggested hypertrophy of the myocardium, subsequently confirmed macro- and microscopically. With the development of hypertrophy of the cardiac muscle the pulse always became rather slower. This can be regarded as a favorable prognostic sign, indicating high reserves of power of the heart. In certain dogs with long-standing functioning aneurysms (over a year) the slowness of the pulse was so pronounced that the difference from the preoperative rate was abolished; Dobrovol'skii's sign was however always present in these cases.

The x-rays obtained showed increase in the heart dimensions, usually developing gradually over a period of several months. Immediately after the formation of the aneurysm it was not possible to find any difference from the original condition (silhouette). The development of this feature was seen more clearly in animals with double femoral arteriovenous fistulae of large size, although the enlargement was observed also in the case of a single femoral fistula (Fig. 2, a, b). In every animal we observed changes in the contour of the heart up to a certain limit. The degree of enlargement, however, was directly proportional to the load on the heart resulting from the development of the pathological anastomoses.

In all the experimental animals, changes were observed in the cardiac rhythm, which was increased in rate. With the formation of a second arteriovenous fistula in the same animal, a new rise in the rate of cardiac contractions took place. On compression of the fistula or of the artery leading to it the pulse was slowed (the so-called Dobrovol'skii's sign). The degree of quickening of the rhythm of cardiac activity increased with increasing diameter of the fistula (see table) and its nearness to the heart. These features observed have a reflex mechanism [1] and are characteristic of the adaptative reaction of the cardiovascular system to the altered conditions of the circulation.