

AUGMENTATION OF THE EXTRACARDIAC ANASTOMOSES
OF THE CORONARY ARTERIES THROUGH PERI-
CARDIAL ADHESIONS

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PLATE 54

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In the preceding paper, the authors (3) have described the origin and distribution of the anastomoses of the coronary arteries with the vessels of the other thoracic structures. The extent of the participation of this collateral circulation in the event of coronary sclerosis is hypothetical, but it seems entirely probable that such occurs and is at least in part responsible for the survival of individuals in whom both coronary arteries have become occluded at their ostia. A satisfactory demonstration of the correctness of this hypothesis would rest upon arterial injection studies in such cases and it is to be hoped that such investigations will be carried out.

Redwitz (5) and Croke (1) each have reported cases of bilateral occlusion of the coronary orifices in which they observed a network of dilated vessels extending from the adventitia of the aorta and pulmonary artery to the non-occluded portions of the coronary arteries. Gross (2) suggested the importance of the extracardiac anastomoses in a case of subtotal occlusion of the right coronary artery without infarction, in which the development of the vascularized fat on the right side of the heart was especially prominent. He felt that the coronary branches to the pericardial fat served as a "compensating structure whose functional possibilities increase in direct proportion with age; that is, with that time of life when pathological processes would make an increasing, more frequent and greater demand upon it." This conclusion is directed at the usefulness of the rami telae adiposae in serving as collaterals between the two coronary arteries, but since they are also important, in providing anastomoses between the coronary arteries and the vessels of surrounding structures (Langer (4), Robertson (6), Woodruff (8), Hudson, Moritz and Wearn (3)), an even greater importance may be attached to an increase in their numbers.

The natural corollary to the demonstration of the extracardiac coronary anastomoses would be that whatever vascular reserve such a collateral circulation might provide would be increased in the event of vascularized adhesions between the pericardial surfaces. Thorel (7) reported a case of a man 68 years of age who died of carcinoma and at autopsy both coronary arteries were found to be obliterated in their proximal portions. The obliteration was of a character judged to be of long duration. The existence of extensive pericardial adhesions was thought by him to have provided an adequate collateral circulation through the vessels of the parietal pericardium.

Four hearts with partial or complete pericardial obliteration by fibrous adhesions were injected by way of the coronary arteries in the manner described in the previous paper.

Case 1 (3955).—A white man, 54 years of age, died of carcinoma of the stomach. At autopsy the pericardium was found to be completely obliterated by fibrous adhesions and the parietal pericardium was adherent bilaterally to the pleurae, the surfaces of which were also fused locally by fibrous adhesions. The heart was not enlarged.

In addition to the coronaries, the vessels of the parietal pericardium were filled by injection mass, and the adhesions between the pericardial surfaces were so extensively injected as to appear almost uniformly black.

Microscopic examination of sections including the myocardium and attached parietal pericardium, showed the intervening tissue to be richly vascularized with vessels filled by injection mass.

The coronary arteries were patent throughout and were the seat of only mild intimal sclerosis.

Case 2 (3884).—A white man, 40 years of age, died of gradually progressive cardiac failure due to rheumatic heart disease. At autopsy, rheumatic pancarditis was found, with chronic mitral, aortic and tricuspid valvulitis, cardiac hypertrophy and dilatation, and extensive pericardial adhesions over the anterior surface of the heart. There was a complete injection of the vessels of the parietal pericardium which were especially numerous at the site of the adhesions. Injection mass was seen in the vessels of the diaphragm and of the trachea and bronchi. The coronary arteries were free from sclerosis.

Microscopic examination of sections through the pericardial adhesions disclosed many vessels extending from epicardium to parietal pericardium, filled with injection mass.

Case 3 (3883).—A white woman, 50 years of age, died of congestive heart failure due to rheumatic heart disease. At autopsy rheumatic pancarditis was found with chronic mitral, aortic and tricuspid valvulitis, cardiac hypertrophy and dilatation,

and complete obliteration of the pericardial sac by fibrous adhesions. There were scattered pleural adhesions over both lower lobes. The coronary arteries were the seat of only mild intimal sclerosis.

The parietal pericardium was richly vascularized and the vessels were filled with injection mass. The adhesions between pericardial surfaces were rendered black by injection of their vessels.

Microscopic examination of sections, including the adherent pericardial surfaces, disclosed many vessels filled with injection mass. These vessels extended from the remnants of the subepicardial fat out into the parietal pericardium. They were not limited to areas usually the site of subepicardial fat deposits, but were seen bridging the obliterated pericardial space in sections taken from many different portions of the heart.

Case 4 (4000 P).—A white man, 34 years of age, died of tuberculous meningoencephalitis. At autopsy the pericardial sac was found to be completely obliterated by richly vascularized granulation tissue in which there was a thick dissemination of miliary and small conglomerate tubercles. The adhesions between heart and diaphragm were particularly dense and the entire under surface of the diaphragm was covered by tuberculous granulation tissue. The heart was moderately enlarged. The coronary vessels were normal.

Before the coronary arteries were injected all of the peri- and intervascular reflections of the parietal pericardium were cut. In addition, all of the great vessels were cut at the ostia so that the normal sites of anastomoses between cardiac and extracardiac vessels were destroyed. On injection of the coronary arteries, however, there was extensive injection of the vessels of the parietal pericardium with filling of the main trunks of the pericardiophrenic arteries. The injection of the phrenic arteries was especially marked and the vascularized granulation tissue on the inferior surface of the diaphragm became almost uniformly black. The presence of intravascular injection mass was verified by microscopic examination.

SUMMARY

The examination of four hearts, with partial or complete obliteration of the pericardial sac by fibrous adhesions, after injection of the coronary arteries with a colloidal suspension of lamp black showed that the extracardiac anastomoses of the coronary arteries were increased owing to the presence of adhesions. In all four instances a particularly rich injection of the parietal pericardium was obtained and microscopic examination of the adhesions showed them to contain injected vessels, extending from epicardium to parietal pericardium. A microscopic study of cleared blocks (3 mm. in thickness) of myocardium and attached pericardial adhesions, showed the arborization

and anastomosis of branches of the arteries of the parietal pericardium with those of the heart. This vascularization was not limited to the usual areas of subepicardial fat, but was seen in regions not ordinarily containing arterial branches. In no one of the four cases were the coronary arteries significantly diseased.

In one of the four cases, the normal sites of anastomoses between the cardiac and extracardiac vessels were destroyed by cutting away the great vessels entering and leaving the heart, as well as the peri- and intervascular reflections of parietal pericardium. Injection mass was found however, in the arteries of the parietal pericardium and the diaphragm, showing that it has passed directly through the adhesions from coronary to extracardiac vessels.

If the extracardiac anastomoses of the coronary arteries constitute a significant reserve for cardiac circulation, it would appear that this reserve would be augmented by the presence of pericardial adhesions. Direct communication between branches of the coronary arteries and the pericardial branches of the internal mammary arteries with free anastomosis with the anterior branches of the thoracic aorta is established over areas corresponding to the extent of the adhesions. Work is now in progress in this laboratory to study the functional significance of such an experimentally induced collateral circulation in experimental coronary occlusion.

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EXPLANATION OF PLATE 54

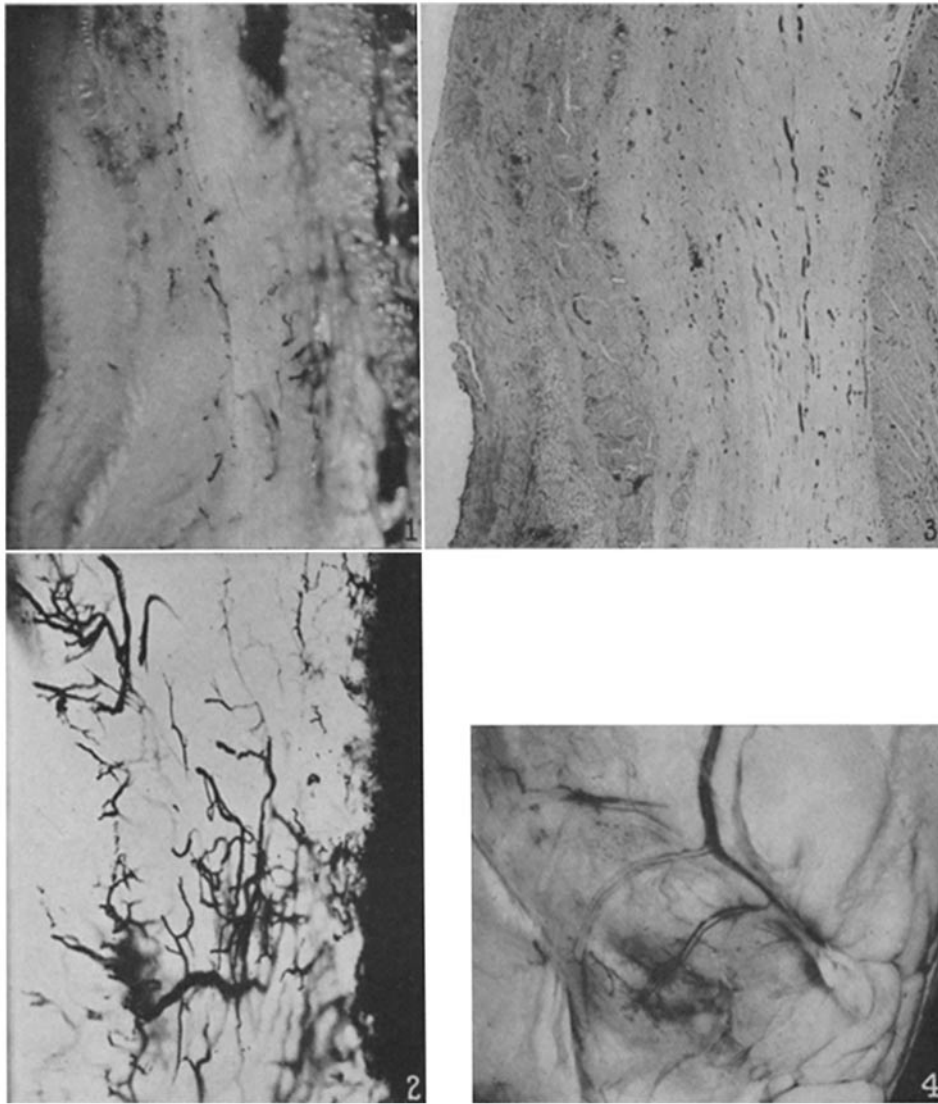
FIGS. 1, 2 and 3. Three photographs of the same block of myocardium with attached fused visceral and parietal pericardium. The coronary arteries were injected with a suspension of lamp black, and the injection mass passed between epicardium and parietal pericardium through the vascularized adhesions. (Case 3.)

FIG. 1. Formalin-fixed block. $\times 7$.

FIG. 2. Cleared block. The anastomoses between vessels of parietal pericardium and epicardium are seen. $\times 7$.

FIG. 3. Microphotograph of section from same block stained by hematoxylin and eosin. The adhesions are dense and fibrous and there is considerable indurated fat adherent to the outer surface of the parietal pericardium. The injection mass has dropped out of some of the larger vessels. $\times 10$.

FIG. 4. Photograph of parietal pericardium including injected pericardiophrenic artery (Case 4). The great vessels were cut at their ostia and the natural reflections of the parietal pericardium were all cut. The pericardial vessels were injected through the vascularized adhesions from the coronary arteries. Three-fourths natural size.



(Moritz *et al.*: Anastomoses of the coronary arteries)