Acute Vascular Lesions in Developing Coronary Collaterals

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Summary. Three weeks after the onset of progressive obliteration of the left circumflex coronary artery a number of small arteriolar preexistent collaterals develop into small arteries. Acute focal lesions, localized in the central parts of the collateral, are described at the light microscopic and at the ultrastructural level.

Partial necrosis of the medial smooth muscle cells, leakage of bloodborne elements through gaps and breaks in the intima, and proliferative activity in neighboring parts of the injured zone are the most characteristic features in the early development.


Typische Merkmale dieses frühen Entwicklungsstadiums sind: Nekrose zahlreicher glatter Muskelzellen der Media, Eindringen von Blutzellen und Plasma durch Lücken der Intima und Proliferation in der beschädigten Zone benachbarten Gebieten.

Injury to arteries has been induced experimentally by a variety of physical (Still, 1967; Hoff and Gottlob, 1968; Cotran and Remensnyder, 1968; Björkerud, 1969) and chemical (Buck, 1962; Hoff and Gottlob, 1967; Gardner and Matthews, 1969) means.

In their experiments on chronic occlusion of the left circumflex branch in canine hearts (Schaper, 1967; Schaper, Schaper, Xhonneux and Vandesteene, 1969) the development of collaterals as early as 2–3 weeks after implantation of an ameroid constriction was noted. Recently the morphology of the evolution of coronary anastomoses was studied at the ultrastructural level (Schaper, Borgers and Schaper, 1970). Near the time the occlusion was completed severe alterations were observed in the newly developing collaterals caused by acute hemodynamic mechanical trauma.

In the present study the evolution of the vascular injuries along the longitudinal axis of the collateral is reported, indicating the focal nature of the lesion and the involvement of the area surrounding the damaged zone.

Material and Methods

Adult mongred dogs of either sex were used in these experiments. The development of collaterals was induced by progressive constriction of the left circumflex artery by means of an ameroid constrictor (Litvak, Siderides and Vineberg, 1957; Schaper, 1966).

Three weeks after the implantation of the constrictor, the animals were anesthetized and the hearts were fixed in situ by perfusion of a freshly distilled (Fahimi and Drochmans, 1965) solution of 2% glutaraldehyde in sodium-cacodylate buffer 0.1 M, pH 7.4, for 5 minutes. It
was very easy to identify macroscopically the epicardial collaterals connecting the anterior descending artery with the left circumflex artery. The collaterals were rapidly excised, divided into small segments, numbered from stem to reentry, and further fixed for 2 hours by immersion in 3% glutaraldehyde. After rinsing overnight in Veronal-acetate buffer, containing 0.2 M sucrose, the blocs were postfixed in 1.5% osmium tetroxide for 1 hour, stained with uranium acetate, dehydrated in graded series of ethanols and embedded in Epon.

The ultrathin sections, after post-staining with uranium acetate and lead citrate, were examined in a Hitachi HS 8-1 electron microscope. For light microscopy paraffin sections of glutaraldehyde fixed blocks were stained with Hematoxylin-Eosin and with Weigert’s resorcin fuchsin. One micron thick sections of Epon embedded segments served as indicators for exact topographical localization of the lesions. These sections were stained with Paragon-1301 (Spurlock, Skinner and Kattine, 1966). Segments of pre-existent collateral junctions, taken from the same region as described above, of control dogs were processed in the same way, for both light and electron microscopy.

Results

A total of 12 collaterals from 4 experimental dog heart were examined and compared with the normal vessel architecture of control dog hearts.

Although the topographical distribution of the morphologic modifications observed in this early stage of vessel growth is the same for all the collaterals definite variations in intensity of the lesions were noted. This probably depended upon the initial vessel size and upon the number of preexistent collaterals before inducing the growth.

The following observations are restricted to the small collaterals which we presumed to respond in the most severe manner to hemodynamic changes occurring at the time of complete occlusion of one major vessel.

Light Microscopy

Control Animals. As for the experimental dogs the small collaterals were divided in segments, numbered 1 to 5 from stem to reentry. A gradual decrease in the vessel radius and the medial wall thickness was prominent from segment 1 to 4, ranging from 500 μ and 8 medial muscle layers in segment 1 to 35 μ and 1–2 medial muscle layers in segment 4. The radius and wall thickness increased again in segment 5.

The normal picture of a collateral junction showed continuously arranged endothelial cells with the underlying elastic lamellae, a closely packed thin layer of smooth muscle cells and the joining adventitia. No mitotic activity was observed in any layer.

Experimental Animals. The segments near the stem or reentry had a normal appearance. In Weigert stained sections a continuous elastic layer, closely opposed to the endothelium was observed. No modifications in medial or adventitial architecture were found.

Segment 2 and 3: the modifications found in these parts of the collaterals were rather similar, although more pronounced in 3 than in 2. Both showed definite alterations in a segment involving 1/8 of the vessel in segment 2 to half the vessel in segment 3. Endothelium and elastic lamellae looked well preserved, although intimal diapedesis was frequent. Abnormally large cells filled the media and some of them were found in mitosis (Fig. 1).

A more pronounced mitotic activity was shown in cells occupying the broad adventitia. Leucocytes, probably infiltrating from veins and venules situated in the vicinity of the artery, were abundant in this zone.