BIOLOGICAL SIGNIFICANCE OF PROTECTIVE MECHANISMS INHERENT IN THE MYOCARDIUM

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Read before the Academy Wednesday, November 16, 1932

To the clinician who sees the effects of disease in the living patient and to the pathologist who observes the evidences of disturbed function and altered morphology in the tissues removed by the surgeon or obtained at autopsy, it appears that all too often the most important structures of the body are those which are most vulnerable. Since the serious morbid lesions and those which are lethal are the most impressive, it is easy to understand the basis for this assumption. Evidence can be adduced, however, that to some degree such necessary structures as the myocardium have acquired certain inherent protective mechanisms which are not equally operative in many other tissues of the body. Some of these protective factors have obvious mechanistic explanations, while others are due to inhibiting actions which are without adequate explanation at the present time.

One of the most obvious of the protective mechanisms of the myocardium is dependent upon the pattern of the arterial blood supply. Not only is there a variable anastomosis between the branches of the right and left coronary arteries, but the number of these connections probably increases as age advances, so that the heart becomes better prepared to withstand occlusive coronary disease in that very period of life when such lesions are prone to occur. Also there is found in the myocardium a peculiar intermingling of arterioles derived from different arterial branches. Thus it is often seen that the necrosis of infarction following occlusive coronary disease will alternate in distribution with patches of intact muscle. This is especially well seen when such lesions reach the stage of fibrosis. Because of the interdigitation of two regionally independent arterial systems the myocardium is able to withstand the occlusion of one of the smaller coronary branches without danger of rupture or aneurysm formation. If the same amount of necrotic muscle or of scar tissue were concentrated in a single area death would be inevitable.
The myocardium enjoys comparative immunity from metastatic malignant disease. It is probable that no biological significance, in the sense of evolutionary modification, should be attached to the ability of the lungs to retain neoplasm cells which might otherwise find their way into the myocardium. This function of the lungs is obviously of minor import compared to that of aeration of the blood. However, even in those cases in which hematogenous skeletal and visceral metastases are present the myocardium almost always escapes. That this is not due to purely mechanical factors is indicated by the fact that with certain neoplasms, as, for instance, the melanoblastomas, the myocardium may contain a large number of secondary tumors.

In infectious diseases similar phenomena may be present. Of all of the internal organs the aorta is most frequently the site of macroscopically and microscopically demonstrable syphilis. While both congenital and acquired syphilis of the myocardium are by no means rare, it is frequently noted at autopsy that acquired syphilitic aortitis with easily demonstrable spirochetes may extend to, and involve, the aortic valves without gross or microscopical evidence of invasion of the myocardium. It is by no means clear why there should not be an invasion of the heart muscle similar to that of the first portion of the aortic arch. It is true that the examination of many blocks from such hearts will usually show active syphilitic foci. The limited extent of such foci, and particularly the paucity of spiral organisms in them, is very often in sharp contrast to the condition in the aorta. That this is not an essential, or an unvarying characteristic of heart muscle is shown by the extraordinary involvement of the myocardium in many cases of congenital syphilis in which spirochetes may be found in tangled masses throughout the interstitial tissue. There are also examples of diffuse and active acquired syphilis of the myocardium with many spiral organisms, but such are comparatively rare. It is evident that some protective mechanism must be operative which in many hearts restricts syphilitic disease to minimal, and more or less latent, foci.

A striking example of the principle under discussion occurs in human trichinosis. Death from massive infestation with trichinae may be due to circulatory failure in the fourth to seventh week of the disease. In such cases the embryos in enormous numbers will be found in an early stage of encystment in the skeletal muscles. In the myocardium, however, not a single embryo can be found, although a characteristic active interstitial myocarditis with numerous areas of lymphocyte and eosinophile cell infiltration is present. Necrotic heart muscle fibres also occur. While some have believed that this myocardial damage with its subsequent inflammatory reaction is of toxic origin, there is experimental evidence that the embryos reach the heart muscle during the period from the eighth to the twelfth day after ingestion just as they do the voluntary muscle.
By the fourteenth day inflammatory foci are present but the embryos can now be found only with great difficulty, if at all. Either they have been killed and have disintegrated, or they have passed back into the circulation. As far as size is concerned, heart muscle fibres would be adequate for encystment of embryos of trichina. Yet something prevents this process. The protection is not altogether adequate, however, for an interstitial myocarditis results.

From such diverse examples as these one must conclude that the myocardium possesses certain protective mechanisms which seemingly are inherent. It is reasonable to consider that these mechanisms are of deeper biological significance than their immediate objective manifestations, and that they have been developed and perpetuated in order to maintain, insofar as possible, the integrity of the myocardium, so essential for the preservation of the organism. It is probable that many of the varied responses of body tissues to extrinsic pathogenic factors have similar significance. Conversely, the recognition of these inherent protective mechanisms, particularly as they occur in different forms of life, may be of use in interpreting generic relationships.

METACHRONISM IN CILIATED EPITHELIUM

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Communicated January 18, 1933

Cilia are remarkable not only because they beat, but because they possess the ability to act in sequence—metachronously. This metachronism or coordinated rhythm results in the production of waves of activity which pass over the ciliary field. The direction toward which such propagated waves travel may be the same as the direction of the effective stroke of the individual cilia, or the reverse. In any given case, however, the same relation of the effective stroke to the wave of propagation is constantly maintained. Thus, in the intestine of lamellibranchs, both are always directed away from the stomach and toward the anus, while in the palate of Rana pipsiens the two are always in direct opposition. In those few cases, notably among the Protozoa and some of the Coelenterates, where a change in the direction of the effective stroke may occur there appears to be a coincident reversal in the direction of movement of the wave propagation. The cirri of the gills of Nephthys beat at a right angle to the wave of propagation and a similar relation exists in the lateral cilia of the gills of lamellibranchs.