

MORPHOLOGY AND PATHOMORPHOLOGY

CHROMAFFIN TISSUE AND SOURCES OF CATECHOLAMINES IN THE VERTEBRATE HEART

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According to current views, the sources of catecholamines in cardiac muscle are sympathetic nerves, chromaffin cells of myocardium, and blood bringing adrenaline and noradrenaline from the adrenal glands [14].

It has been shown that sympathetic nerves constitute the main source of noradrenaline in cardiac muscle [1, 2, 9]. The evidence of the presence of chromaffin cells in the myocardium is mostly indirect [6, 7, 8, 11, 13]. There have been few histological investigations dealing specifically with the presence of chromaffin cells in the myocardium. Cells giving chromaffin reactions have been found in the myocardium of *Myxine* and the lamprey [4, 5, 12], near the inner surface of the frog ventricle [7], and in the atria of the dog [16].

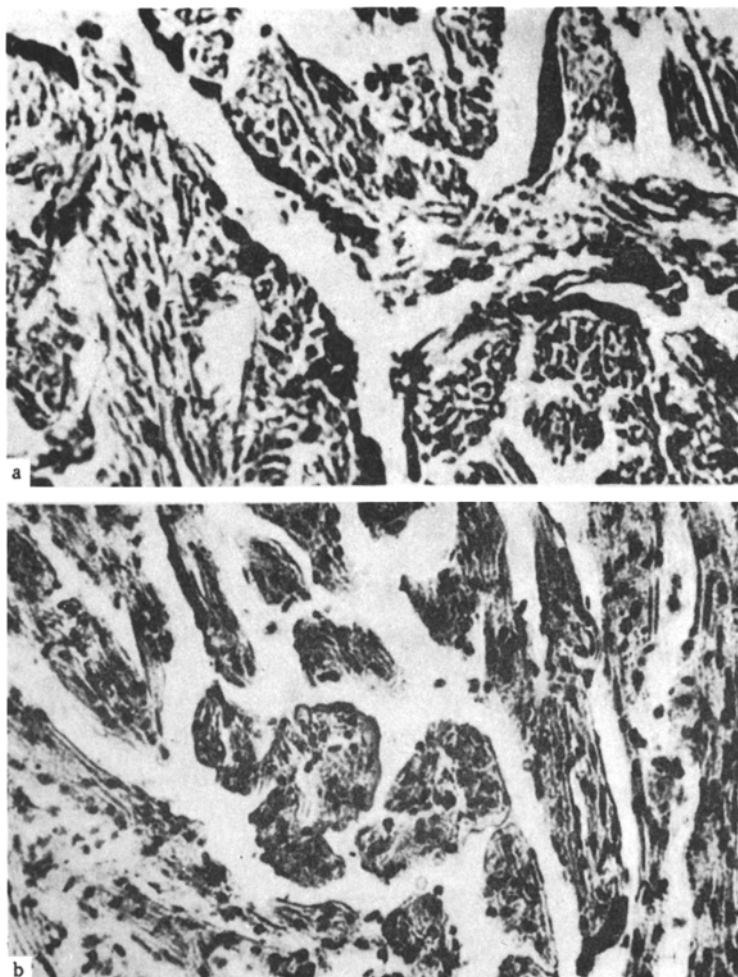
In this investigation the heart muscle was examined for chromaffin tissue in representatives of various vertebrate classes: cyclostomes (river lamprey), fishes (common roach), amphibians (frog), reptiles (Central Asian tortoise), birds (4- and 6-day chick embryos, 3 day old chicks) and mammals (albino mice, rats, cats). Paraganglia situated outside the heart were not examined.

METHODS AND RESULTS

The Hillarp and Hökfelt [10] and Ort [15] methods, supplemented by staining of some sections with 0.05-0.1% toluidine blue, were used for the detection of chromaffin cells. It was found that, in order to demonstrate these cells in the myocardium by the Hillarp-Hökfelt method, the reaction time had to be increased from 16 h to 3 or 4 days. Chromaffin cells were then seen quite distinctly (in the lamprey heart in these experiments).

Numerous cells, elongated, oval or, less frequently, circular in form, which stained a yellowish-brown color with chrome salts were found in the cardiac muscle of the lamprey. These cells were situated on the surface of the muscle wall of the lacunae and formed aggregations at some points. There were more of them in the atria than in the ventricles (Fig. 1). After fixation in formalin, the cells stained selectively an intense blue color with toluidine blue itself or, after application of the Hillarp-Hökfelt or Ort treatment, a greenish color. These cells are apparently identical with the special cells containing chromaffin granules which have already been described [5] in the hearts of the lamprey and *Myxine*. It is a remarkable fact that chromaffin cells were found only in the lamprey heart. The most careful examination of preparations from the hearts of fishes, amphibians, reptiles, birds and mammals failed to reveal any similar cells, even though serial sections were prepared from individual fish, frog and mouse hearts so that the entire heart could be examined. An attempt to demonstrate chromaffin cells in frog heart muscle by the chromic acid method used by Chakravorti [7] was unsuccessful.

The hearts of 4- and 6-day chick embryos were examined for chromaffin elements in some special experiments. The authors had found earlier [1] that the heart of the 4 day chick embryo, still without sympathetic innervation, contained a relatively large quantity of adrenaline but no noradrenaline. They were unable, however, to discover any structures reacting selectively with chrome salts in the hearts of such embryos. This would indicate that the heart muscle cells themselves are the probable source of adrenaline in the heart still without nerves. Reactions for



Chromaffin cells in lamprey heart. a) Atrium: aggregations of chromaffin cells. b) Ventricle: single chromaffin cells. Hillarp-Hököfelt reaction for chromaffin tissue and subsequent staining with toluidine blue. 140 \times .

chromaffin tissue were likewise negative in the hearts of 6 day chick embryos, which already have sympathetic innervation.

The feeble chromaffin reaction peculiar to the actual muscle cells of the lamprey heart [5] was also observed in our experiments. This is further proof of the presence of catecholamines actually in the cardiac muscle cells. Udel'nov [3] has suggested that catecholamines are derived from actual muscle structures and not from nerve endings, but with the latter statement at any rate, it is hardly possible to agree [1, 2, 9, 14].

These experiments would appear to indicate that chromaffin cells producing catecholamines are present in the cyclostome heart only and that the muscle cells themselves in the vertebrate heart may constitute a source of adrenaline.

SUMMARY

The myocardium of all the classes of vertebrate animals, excluding the cyclostomata, contains no chromaffin tissue. Muscular fibers of the cyclostomata heart are slightly chromaffin reactive. No chromaffin elements are contained in the anervous heart of chick embryos.

In the authors' opinion one of the sources of catecholamines in the heart is the muscular tissue itself.

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