DNA Synthesis and Mitoses in Atrial Myocytes of Rats with Aortal Stenosis

Heart hyperfunction activated ^{3}H-thymidine incorporation into nuclei of stroma and blood vessel cells[1–4], while the labelling of numerous ventricular myocytes nuclei was observed only rarely[5]. In this work proliferative behaviour of atrial and ventricular myocytes of 32 female white rats (165–185 g) with severe stenosis of abdominal aorta (made as in [2,4]) was compared, taking into account striking differences in the capacity of these cells to synthesize DNA and to divide mitotically[6–8]. 3–18 days after operation and 2 h before killing, experimental as well as control (intact) rats were injected with 0.8 μC/g of ^{3}H-thymidine (specific activity 0.33 C/mM); 3 rats received 5 injections (at 10.5 h intervals) of ^{3}H-thymidine beginning from the 12th day after operation. In radioautographs prepared as in [2,4,7,8], the percentage of labelled nuclei (LI) and that of mitoses (MI) was determined by scanning at least 1000 myocyte nuclei.

The 2nd and 3rd weeks after operation, the mean weight of whole hearts and that of left ventricles increased ($p < 0.05$) by 25–50% (Figure 1). In right ventricles of the majority of rats, numerous and extensive necroses were seen. Similar necroses were observed in right auricles of 40–50% of animals and more rarely in left ventricles and atria. The muscle fibres of all heart chambers, especially in left ones, were often thickened.

In ventricles of control and operated animals, DNA-synthesizing nuclei and mitoses belong as a rule to cells of stroma, blood vessels or granulation tissue, which agrees with [1–4]. Only in several rats (11–17th days after operation) 1–3 striped muscle cell labelled nuclei (Figure 2, a) were observed per section of left or, more often, of right ventricle, containing 3000–5000 or more muscle nuclei. 3 mitoses of ventricular myocytes were found in all experimental material, the control animals being completely devoid of both unequivocally labelled and dividing ventricular myocytes. The same results were obtained after repeated injections of ^{3}H-thymidine, except for myocytes around granulation tissue areas in right ventricle of 2 rats; LI for these myocytes attains 0.7 and 1.2%, respectively.

The behaviour of atrial myocytes was different. Even in atria of 6 of 10 control rats there are some rare myocyte nuclei incorporating ^{3}H-thymidine or dividing mitotically; the mean LI for all 10 rats (including 'nullers' ones) is 0.104 ± 0.073% and MI – 0.060 ± 0.022% (Figures 1 and 3). During the 3rd–10th postoperative days both LI and MI for the bulk of atrial myocytes differs little from control values. However, at the end of the 2nd week, in left and right atrium of many animals unusually high number of myocyte labelled nuclei and mitoses can be observed

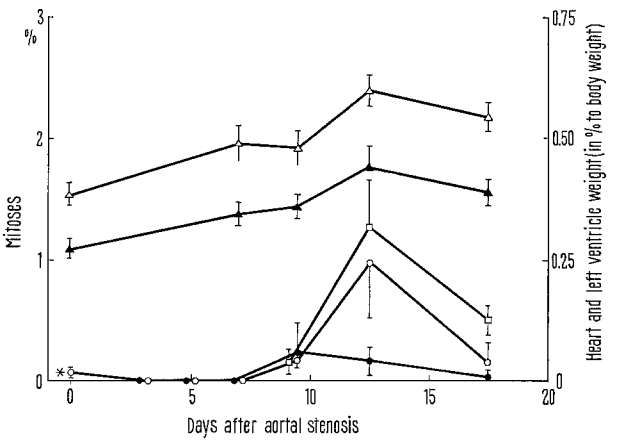

Fig. 1. Changes in the whole heart weight (hollow triangles), left ventricle weight (filled triangles) and percentages of mitoses in myocytes of left atrium (hollow circles), right atrium (filled circles) and those around necrotic areas in the right atrium (squares) at different stages after constriction of aorta in rats. Each point is average for 5–6 animals (that with asterisk for 10 animals, squares for 3–4 animals, 3 and 5 days points for 2 animals), vertical bars are S.E.M.

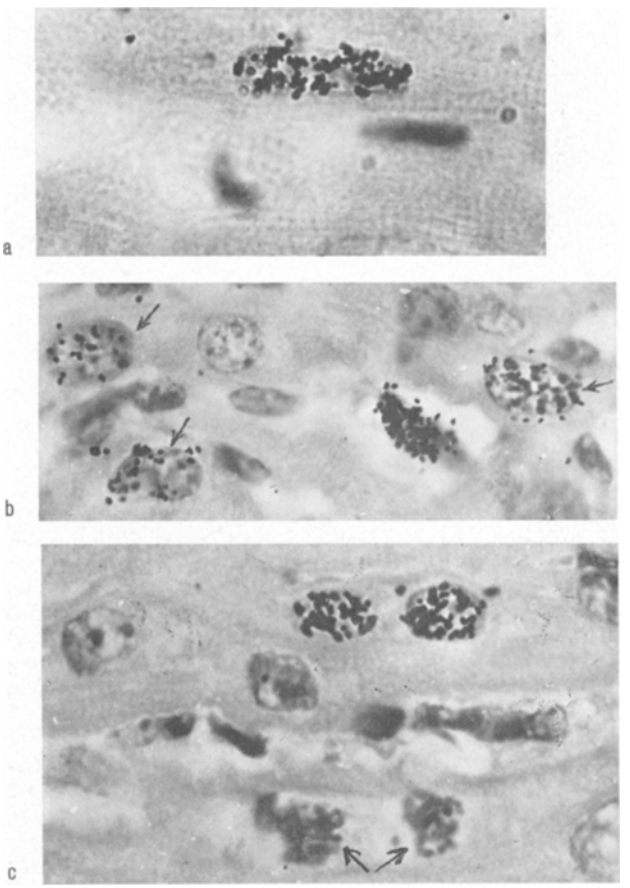

Fig. 2. Labelling of myocyte nuclei at the 13th day after constriction of aorta in rats. 2 h after ^{3}H-thymidine injection. a) a Rare case of myocyte nucleus labelling in the left ventricle. b) Labelling of 3 myocyte nuclei (arrows) in the left auricle. c) Synchronous synthesis of DNA in 2 adjacent muscle nuclei (dicaryotic myocyte?) and unlabelled myocyte telophase (arrows) in the right auricle. × 1150.

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(Figures 1, 2 and 3). If the mean LI for left atrium myocytes of all rats killed at the end of the 2nd week attains $1.60 \pm 0.59\%$, which is 15 times more than control values ($p < 0.05$), atria of several rats contained as many as 3–5% of labelled muscle nuclei; the sum of LI and MI attains in some animals 4–7%. Repeated injections of ^{3}H-thymidine result in labelling of 0.2, 2.1 and 5.8% of all myocytes in left atria of 3 rats, respectively. The degree of DNA synthesis activation was found to be similar both in left and right atrium myocytes (Figure 3), while mitoses were numerous only in the former ones. By the 3rd week, proliferation of auricular muscle nuclei is reduced clearly (Figures 1 and 3). As compared with the above data, DNA synthesis in the myocytes bordering the necrotic areas in atria was activated by 5–7 days earlier and 2–3 times more intensively (Figure 3).

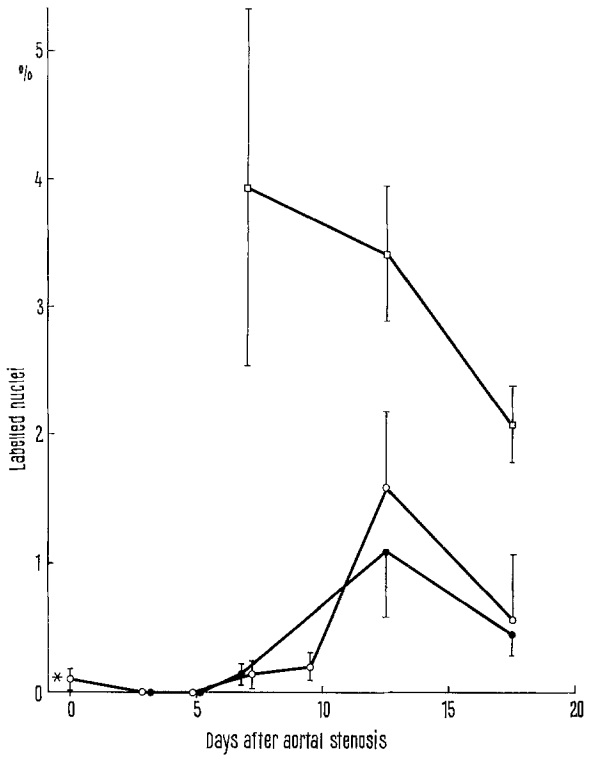

Fig. 3. Percentages of ^{3}H-thymidine labelled myocyte nuclei in the left atrium, right atrium and in perinecrotic myocardium of the right atrium at different stages after aortal stenosis in rats. Designation of points and the number of animals as in Figure 1.

Extreme individual variations of both LI and MI values are quite typical (Figures 1 and 3), indicating the inconstancy and/or partial synchronization of the reactive hyperplasia of highly differentiated heart muscle cells.

Thus both left ventricle hyperfunction and infarction[6–8] are followed by reactive hyperplasia of differentiated atrial myocytes which is somewhat belated as well as less intensive and regular in the bulk of hypertrophied heart auricular myocardium. It must be taken into account in the studies on the pathogenesis of different forms of heart failure.

Выводы. Гиперфункция и гипертрофия сердца при стенозе аорты сопровождаются у многих крыс активацией синтеза ДНК и митозов в миоцитах как левого, так и правого предсердий. Реактивная пролиферация максимальна к концу 2-й недели после коарктации аорты, когда $1{,}60 \pm 0{,}59\%$ всех миоцитов левого предсердия синтезируют ДНК, а $0{,}96 \pm 0{,}44\%$ – делятся митозом. Ещё более интенсивно размножаются миоциты вокруг некротических очагов в предсердиях. Напротив, в желудочках обнаружены лишь единичные меченые H^3-тимидином ядра.

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Cilia in Axolotl Neurons (*Siredon mexicanum*)

The occurrence of cilia in neurons and glia of the mammalian nervous system described by del RIO-HORTEGA[1] as early as 1916 is now a well-established fact[2–15], but few references are available about their existence in the nervous tissue of lower forms[16,17]. The purpose of this note is to describe this organoid as seen in spinal cord neurons of the aquatic salamander *Siredon mexicanum* (Axolotl) and to suggest that the presence of cilia in nerve cells may be more widespread through the central nervous system in the various animal phyla than previously assumed.

Materials and methods. A series of 50 spinal cords either in situ or implanted for variable lengths of time into the dorsal fin of a host axolotl[18] were fixed by immersion in a variety of aldehyde mixtures, and post-fixed in osmium tetroxide, followed by aqueous saturated uranil acetate and embedded in Epon. Ultra-thin sections were stained with lead acetate and studied under a Siemens I electron microscope. Thick (1 μm) sections of the same material were stained with 1%, pH 7.4, toluidine blue and observed under the optical microscope.

Results. A number of ciliated neurons were found in the spinal cords both in situ and in the implants. Identification of the cells as neurons was made on the basis of their strong similarity to the mammalian neuron, location inside the cord and correlation with optical microscopy observations. Glial cells, on the other hand, are very similar to those described in the spinal cord of the newt[19] and no cilia have been found in these cells so far.

Most of the morphological features observed in the mammalian neural cilia were present here. Figure 1 illustrates a typical longitudinal section of a cilium in a neuron of an implant. The shaft has a diameter of 170 nm, slightly less at its origin, and is bounded by a ciliary sheet continuous with the cell membrane. In the cases where the centrioles remained in their original position in the vicinity of the nucleus, the cell membrane invaginates down to the level of the transition region of the cilium before reflecting on itself to cover the shaft and, as a result, a periciliary sulcus forms with the deepest portion dilated (Figure 1). With approximately the same frequency, however, cilia are found in which the basal body is located in the periphery of the cell so that no membrane invagination occurs (Figure 2). The microtubules inside the shaft have a diameter of about 20 nm and have attached to