REGENERATION OF THE LIVER IN CATS

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The problem of regeneration of the liver has for a long time been the subject of investigation [1], yet many of its aspects concerned with differences in the regeneration of the liver in animals at different levels of organization remain inadequately studied. The question of regeneration of the liver in different members of the class of the Mammalia is especially interesting. In particular, no information could be found in the literature on the regeneration of the cat's liver, apart from isolated reports of the regeneration of the liver after puncture, compression with forceps, or wedge resection [2].

In the present investigation the regeneration of the cat's liver was studied after removal of, not only small pieces, but also whole lobes of the organ.

EXPERIMENTAL METHOD

Experiments were conducted on 60 cats of both sexes weighing from 1120 to 4000 g. In 11 of these animals pieces of different lobes of the liver amounting in all to 33.5 g in weight, or about 30% of the total weight of the

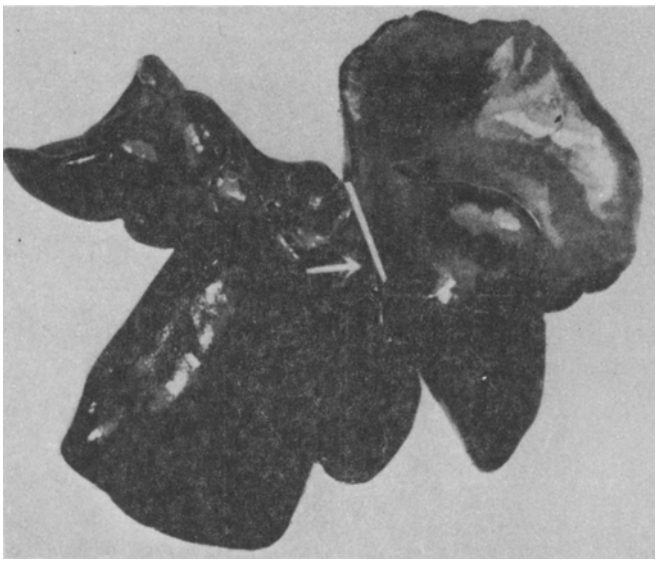

Fig. 1. Intact liver of a cat. Lobes of the liver removed at operation are on the right of the arrow.

Mean Weight of Body and Liver of Control and Experimental Animals at Different Times of Regeneration

Animal	Body weight and weight of liver	Time after partial hepatectomy (in days)					
		1	2	3	4	7	14
Experimental	Body weight at operation (in g)	2,675	2,439	2,513	2,280	2.471	2,576
	Weight of resected lobes of liver						
	absolute (in g)	28.7	30.4	30.9	29.5	28.5	29.6
	relative (in % of weight of liver in controls)	31.4	33.3	33.8	32.3	31.2	32.4
	Body weight at sacrifice	2,500	2,283	2,435	2,128	2,372	2,558
	Weight of residual lobes at sacrifice						
	absolute (in g)	51.1	56.2	64.4	59.7	69.3	88.1
	relative (in % of weight of liver in controls)	55.9	61.5	70.5	65.3	75.8	96.5
	relative (in % of body weight)	2.15	2.64	2.71	3.01	3.14	3.51
Control	Body weight (in g)			2,750			
	Weight of liver						
	absolute (in g)			91.3			
	relative (in % of body weight)			3.46			

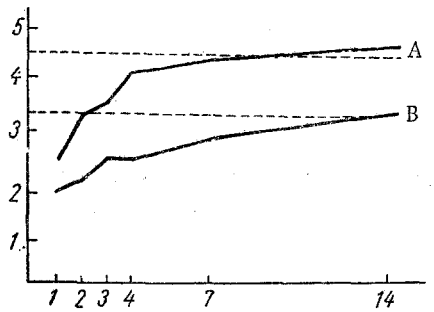

Fig. 2. Changes in relative weight of the liver in the process of its regeneration in young (A) and adult (B) animals. The broken lines indicate the weight of the liver of the control animals of corresponding body weight. Along the axis of ordinates—relative weight of liver (in %), along the axis of abscissas—days after partial hepatectomy.

liver, were removed (experiments of series I). The operations were carried out under Nembutal anesthesia. In the first experiments the pieces of liver were removed by means of a specially made thermocautery without ligation of the vessels. In 41 animals in the experiments of series II two lobes of the liver were removed: the left segment of the central lobe and the lateral lobe (Fig. 1). Eight cats acted as controls. The lobes of the liver were removed through an incision 5-6 cm long in the abdominal wall in the mid-line. Ligatures were tied around the base of the lobes of the liver to be removed, and the lobes were resected below the ligatures. The lobes removed amounted to 31-33% of the total weight of the liver on the average. The residual lobes of the liver were irrigated with rivanol and the wound surface was treated with dry streptocide. Before the wound was sutured, penicillin solution (200,000 units) were poured into the peritoneal cavity.

The experimental and control animals were kept and fed in identical conditions. The cats began to take food 24 h after the operation.

The animals in the experiments of series II were divided into six groups. The cats of group 1 were sacrificed 24 h after the operation, those of group 2—48 h after, group 3—72 h, group 4—96 h, group 5—7 days, and group 6-14 days after the operation. Each group consisted of 6-9 animals. The cats were sacrificed at 8-10 A.M. The liver was extracted after sacrifice, weighed, and fixed in 10% formalin. The total number of liver cells in a field of vision of the microscope and the number of dividing cells were counted in paraffin sections stained with hematoxylin-eosin. The mitotic activity of the liver cells was determined by calculating the number of mitoses occurring in at least 7000 cells in each case.

EXPERIMENTAL RESULTS

The animals from which separate pieces of different lobes of the liver or whole lobes were removed responded differently to the operation. Some cats refused to eat for 2-3 days after the operation, and their condition gradually deteriorated. Most of the animals began to eat soon after the operation and differed little from the control animals in their behavior.

As the results of the experiments of series I showed, the resected pieces of the organ did not regenerate. However, the total weight of the liver 35 days after the operation was invariably the same as in the control animals of the same body weight. Hence, the experiments of series I revealed that the liver of the cat is well capable of regeneration, and with this in mind further investigations were carried out in which whole lobes of the organ were removed. These operations usually took place without any complications, and the animals appeared in a satisfactory state by the second day.

At autopsy of the animals in the experiments of series II at different periods after partial hepatectomy, hypertropy of the remaining lobes of the liver was found, more marked in the late stages of regeneration. Hypertrophy of the lobes of the liver was accompanied by an increase in their weight (see table).

It follows from the table that the weight of the residual part of the liver increased most intensively in the first 4 days. On the following days the increase in weight was slower. By the 14th day its weight in the animals undergoing operation had fully reached the weight of the liver of the control animals.

Analysis of the results from the age aspect shows that the intensity of the process of regeneration of the liver was largely dependent on the cats' age. The weight of the liver was restored most rapidly in the young animals. The relative weight of the liver in these animals was greater throughout the period of regeneration than in the adults, but a more interesting fact was that the increase in the weight of the liver after resection of two lobes took place much faster in the young animals than in the adults. This led ultimately to the almost complete restoration of its weight 7 days after the operation (Fig. 2).

The microscopic investigation of the liver of the animals undergoing hepatectomy revealed no significant changes apart from a slight vacuolation of the cytoplasm of some liver cells in the early stages of regeneration (24 and 48 h after the operation). Counts of the liver cells in the field of vision of the microscope revealed no significant differences between the experimental and control animals, thus demonstrating the absence of any marked hypertrophy of the liver cells during its regeneration after removal of one-third of the organ.

No mitoses were seen 24 h after the operation. After 48 h dividing cells were found in 5 of the 7 cats sacrificed at this time. On the average the mitotic activity was low (0.8 %). The number of mitoses varied considerably from animal to animal—from total absence to 10%. Mitoses were also found 72 and 96 h after the operation, but they were much fewer. The maximal mitotic index 72 h after the operation was 4%. At the later periods of regeneration (after 7 and 14 days) mitoses were very rare. No dividing cells were observed in the control animals.

The experimental findings described above demonstrate the ability of the cat's liver to replace its lost parenchyma after the removal of separate pieces of the organ and the resection of its complete lobes.

Comparison of the character of regeneration of the cat's liver with that observed in other vertebrates leads to the conclusion that in these animals, as in other mammals, after the removal of two lobes of the liver the residual lobes undergo regeneration hypertrophy. The increase in the size and weight of these lobes is due to their quantitative repopulation with liver cells produced by mitotic division.

LITERATURE CITED

1. L. D. Liozner (editor), Regeneration of Organs in Mammals [in Russian], Moscow (1960), p. 199.
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