MORPHOLOGY AND PATHOMORPHOLOGY

Regeneration of the Liver after Partial Hepatectomy with a Beam of Ionized Plasma

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Eighty guinea pigs underwent resection of the left lateral lobe of the liver, performed with a beam of ionized plasma. Morphological analysis 32 and 45 hours after partial hepatectomy revealed minor damage to the parenchyma to a depth of 300-400 μ. Autoradiography showed proliferative activity in the organ to occur in the early postoperative period.

Key Words: *liver; regeneration; ionized plasma*

In connection with the development of plasma surgery we are conducting an extensive investigation of the effects of ionized plasma radiation on biological objects. In particular, genetic experiments on microorganisms and studies of the somatic mosaicism of drosophila ommatidia have revealed no mutagenic effect on the respective cell populations; however, a marked bacteriostatic effect and slight increase of recombination frequency were noted [3,4]. These results raise new questions, including some of practical significance for surgery. One such question has to do with the regenerative capacities of an organ after direct treatment of the corresponding tissue with ionized plasma, i.e., following its resection. This is especially important in the case of the liver, in view of the specific features of its anatomy and physiology, its unique role in the organism, and its multiple vital functions. All this explains the keen interest of surgeons in the results and consequences of plasma resection performed on this particular organ.

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We present here a structural-functional study of liver regeneration after partial hepatectomy with an ionized plasma beam.

MATERIALS AND METHODS

The object of the study was regenerating liver of guinea pigs (80 experiments). All animals, weighing on average 82.0±4.6 g, received ether anesthesia, and following midline laparotomy the left lateral lobe of the liver (weight approx. 3 g) was resected with a SUPR-2M plasma scalpel (current strength 20 A, arc voltage 30 V, gas expenditure 0.4 liter/min). The remaining part of the liver was analyzed 32 and 45 hours postoperation. The method was described earlier [2].

One hour before sacrifice the animals were injected intraperitoneally with ^{3}H-thymidine (specific activity 6.3 Ci/mmol, 0.5 μCi/g body weight). The liver specimens were fixed after Lilly, i.e., with a mixture of 96% ethanol and glacial acetic acid (v/v ratio 3:1) and neutral buffered formalin. Each sample of tissue was divided into two pieces. From one piece sections were made and stained with acetocarmine, affer which the number of

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mitoses was counted and the mitotic index calculated. The second piece was treated with 50% KOH solution in order to dissociate the cells, and the prepared smears were coated with photoemulsion (Ilfond). After a 7-day exposure the autographs were developed, stained with Mayer's hemalaun, and the index of labeled nuclei was recorded. Preparations were also analyzed for structural alterations using conventional morphological criteria.

RESULTS

The liver tissue alterations following plasma resection are composed of several layers (total depth 300-400 μ). The superficial layer (10-20 μ thick) is represented by coagulated yellow-stained blood with features of charring. Then follows a layer of edema and coagulation necrosis (80-100 μ). The tissue is oxyphilic, homogenous, and anuclear. The next layer (100-150 μ) is characterized by a compaction and discomplementation of the liver parenchyma with homogenization of the cytoplasm and swelling of hepatocyte nuclei. At the border with the intact parenchyma areas of intertrabecular capillary hyperemia with enlarged Disse spaces are observed. The hepatocyte cytoplasm has features of cloudy swelling, which may be regarded as a reversible phase of dystrophy. Morphological signs of liver regeneration are still absent in this layer, both in the intact parenchyma and in the damaged regions.

However, early on in the postoperative period the regeneration processes begin, as can be judged from the results of autoradiography. Analysis of labeled thymidine incorporation shows that 32 hours after the partial hepatectomy the proportion of DNA-synthesizing hepatocyte nuclei is equal to 84‰, whereas hepatocytes in the mitotic phase are still not detectable at this phase of regeneration.

The considerable DNA-synthesizing activity of hepatocytes and entry into the S-phase at the normal time provide evidence of active preparation for the proliferative process [1,2]. Forty-five hours after the operation, against the background of continuing DNA synthesis the number of cells in the S-phase is increased almost twofold. Simultaneously a significant hepatocyte proliferation is observed, the frequency of mitoses attaining 36‰, thus attesting to vigorous regeneration in the liver.

The findings allow us to state that plasma resection of the liver causes minimal damage to the organ parenchyma to a depth of 300-400 μ. Direct action of ionized plasma on the parenchyma does not affect the capacity for regeneration, which begins in the early postoperative period.

REFERENCES

1. G. K. Dubovaya, A. A. Kushch, and V. Ya. Brodskii, *Byull. Eksp. Biol. Med.*, **84**, № 8, 221-224 (1977).
2. P. A. Karmanov, N. A. Milyutina, and M. Ya. Nekhlyudova, *Ibid.*, **96**, № 11, 119-122 (1983).
3. I. V. Stupin, A. I. Novokshonov, A. M. Dombrovskii, *et al.*, *Ibid.*, **110**, № 10, 413-415 (1990).
4. I. V. Stupin, A. M. Dombrovskii, A. I. Novokshonov, *et al.*, *Ibid.*, 415-416.