

EFFECT OF THE LASER BEAM ON THE RABBIT LIVER

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Local necrosis of liver tissue, accompanied by hemorrhage and by thrombosis of the blood vessels, takes place under the action of the pulsed laser beam. By means of a continuous laser beam bloodless incisions can be made in the liver parenchyma. The blood supply to the liver tissue at the site of laser lesions is restored by the formation of blood vessels of atypical structure.

Optical quantum generators (lasers) are used in medicine and biology. Because of their coherence and high monochromatic qualities, the possibility of optical focusing, and their high energy densities, lasers can be used in surgery, ophthalmology, stomatology, and oncology [1, 2, 4-7].

The action of laser rays on the liver has been investigated experimentally [3, 8], and the destructive effect of their action on the liver cells has been demonstrated. Nevertheless, the dynamics of healing of foci of laser damage has been inadequately studied. No results of an investigation of the state of

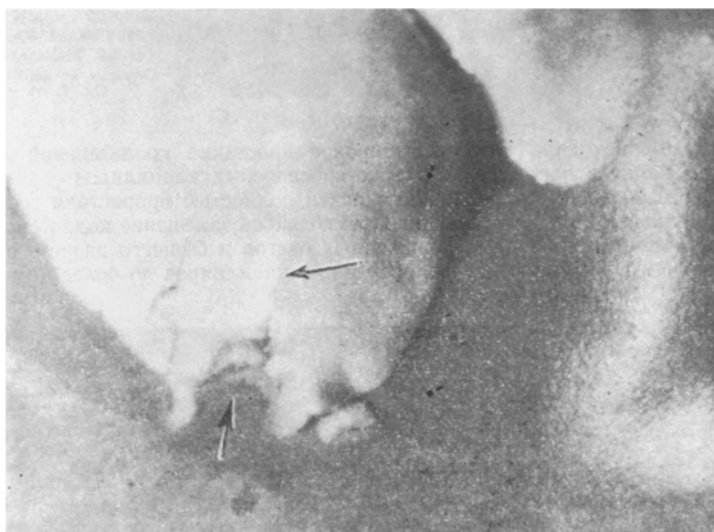


Fig. 1. Liver of a rabbit (anatomical specimen). Arrows show hair and burns in liver parenchyma at the sites of action of the laser beam.

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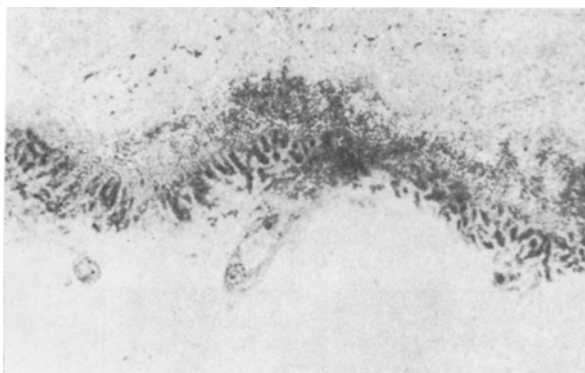


Fig. 2. State of the liver 5 days after irradiation with a pulsed laser beam: a zone of cellular infiltration can be seen around the zone of necrosis of the liver tissue. Van Gieson, 56 \times .



Fig. 3. State of the liver 25 days after division of its tissue by a continuous-action laser beam; blood vessels can be seen in the region of the operation scar. Specimen injected with ink, 56 \times .

the hepatic blood vessels at the site of laser action could be found in the accessible literature. Rapid progress in laser techniques and the appearance of new types of laser apparatus must also be taken into account.

In the investigation described below the action of the beams of two Soviet lasers on the liver is compared.

EXPERIMENTAL METHOD

Two series of experiments were carried out on 47 chinchilla rabbits on which laparotomy was performed in the usual way under local anesthesia with procaine and the liver irradiated. In the experiments of series I the right lobe of the liver was irradiated in 16 rabbits by pulses of a neodymium laser (wave length 1.06 μ , beam diameter 3 mm, pulse duration 0.03 sec, energy 140-160 J, total dose 560-640 J, mean energy density 2300 J/cm²). In series II (31 rabbits) an incision, 7.5 mm² in area, was made in the parenchyma of the right lobe of the liver with a continuous-action laser working on CO₂, with a power of 20 W, beam diameter 2 mm, over a period of 6-15 sec. The mean energy density was 2600 J/cm². It is important to emphasize that no bleeding was observed from the liver incision. In both series of experiments the operation wounds of the liver and abdominal wall were closed with interrupted silk sutures. Between 5 min and 30 days after the operation the animals were sacrificed every 5 days and the liver was investigated histologically at the sites of action of the laser in sections stained with hematoxylineosin and by Van Gieson's method. The blood vessels of the liver also were studied histologically after injection of an aqueous suspension of ink into the aorta.

EXPERIMENTAL RESULTS

Immediately after "shots" of the pulsed laser whitish burned areas 0.3-0.4 cm in diameter, with cratering in the center, appeared on the liver capsule. The edge of the liver was frequently torn (Fig. 1). Slight bleeding observed at the points where the liver tissue was torn ceased of its own accord after 10-15 sec. Histological examination up to 2 days afterward revealed coagulation necrosis with marked disturbance of the circulation near the affected foci, expressed as thrombosis of the blood vessels, especially the capillaries, and hemorrhages. A similar picture of pathological changes in the liver tissue, in the form of necrosis and hemorrhages, was also observed in the region of the liver incision produced by the continuous-action laser in the experiments of series II.

The region of the burn of the liver tissue appeared circumscribed 5 days later, but on histological investigation a central zone could be distinguished in which the trabecular pattern of liver structure was partly preserved and homogenization of the cytoplasm of the hepatocytes with eosinophilia was observed. In addition, nuclei of the hepatocytes with weakened staining properties were found. Outside the zone of necrosis was a zone of accumulation of leukocytes and "nuclear dust," beyond which areas of coagulation necrosis reappeared (Fig. 2). Meanwhile, around the silk sutures (experiments of series II) there were areas of collagen fibers joining the edges of the incision locally in the liver tissue. By the 10th-15th day extensive invasion of growing collagen tissue was found in the area of necrosis in both series of experiments, accompanied by the formation of capillaries in the affected foci.

The areas of necrosis 20 days after the operation were almost completely invaded by connective tissue, and by the 25th-30th day the affected foci and the site of the previous incision were replaced by collagen and elastic fibers with the formation of blood vessels in them ranging from capillaries to larger vessels up to 75μ in diameter. These newly formed blood vessels were of different shapes: constricted, dilated, amputated, curved and so on (Fig. 3).

The following general conclusions can be drawn from these experiments:

- 1) After irradiation of the liver by a pulsed laser beam local burning takes place and coagulation necrosis of the liver tissue, accompanied by hemorrhages by thrombosis of the blood vessels, is observed;
- 2) bloodless incisions can be made in the liver parenchyma by the use of the Soviet continuous-action laser;
- 3) scar formation at the sites of incision of the liver tissue by the continuous-action laser beam takes place from the 5th day after the operation;
- 4) restoration of the blood supply at the sites of action of the pulsed laser and in the region of the incision in the liver tissue made by the continuous-action laser beam takes place within 15-30 days by the formation of blood vessels of atypical structure.

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