EXPERIMENTAL METHODS FOR CLINICAL PRACTICE

Experimental and Clinical Aspects of Laser Destruction of Adenohypophysis

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Focal destruction of the adenohypophysis by Nd:YAG laser does not destroy other structures of the hypothalamo-pituitary region. During reparative regeneration, the focus of coagulation necrosis after laser destruction of the adenohypophysis is replaced by cicatricial tissue. A method for surgical treatment of pituitary adenomas was developed. The efficiency, safety, and low traumatism of this method were confirmed in 87 patients.

Key Words: *highly intensive laser exposure; adenohypophysis*

Pituitary adenomas (PA) rank third by their prevalence among intracranial tumors [5]; in 75% cases they develop in young and middle-age patients [12].

Surgical treatment of PA remains an intricate problem of neurooncology, which is explained by the location of these tumors near vitally important structures: hypothalamus, internal carotid arteries, Willis' circle, cavernous sinuses, and cranial nerves [8,12]. The incidence of grave postoperative complications (nasal liquorrhea, purulent meningitis, wounds of internal carotid artery) remains very high [11,15]. Current methods of surgical treatment of PA, including cryogenic destruction, are technologically difficult, do not guarantee from relapses, and their use is associated with severe complications [12]. Highly intensive laser exposure (HILE) seems to be the optimal method for solving the problem due to monochromaticity, coherence, high energy density, strict direction [3,7], and possibility of delivery of energy to the object via flexible monofiber lightguides through a puncture transnasosphenoidal approach [10]. At present the exposure to high-energy lasers are used as a supplement to surgery for PA as a "light scalpel" [6]. However irradiation with Nd:YAG laser was not used for direct destruction of PA, and therefore the parameters of such exposure of adenohypophyseal tissues were not defined.

The purpose of this study was an experimental morphological substantiation of the possibility of using Nd:YAG laser in surgical treatment of PA.

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MATERIALS AND METHODS

Chronic experiments were carried out on 33 mongrel dogs (20-25 kg). A Raduga Nd:YAG laser (1.06 μ) was used. Adenohypophysis was destroyed at a power of 1.5 W in a continuous mode (120 sec). The operation was performed under local anesthesia with neuroleptanalgesia. A 1-cm incision was made on the soft palate along the median line in a dog lying supine with the mouth maximally open. The incision opened the nasal part of the throat lined with mucosa strongly fixed to the skull base bones, transferring into their periosteum. After dissection of the periosteum (0.5 cm) along the median line, a metal mark for x-ray control, corresponding to the projection of the sella turcica fossa, was placed at the level of the anterior pterygospinous processes of the clinoid bone. As the dogs lack the airy saddle of the main bone [13], a

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3-mm hole was drilled in the main bone under x-ray control and after correction of the direction to reach the sella turcica fossa. A metal cannula was inserted into this hole to a depth of 1-2 mm towards the anteroinferior surface of the pituitary. The position of the cannula was additionally checked up by x-ray. Laser radiation was delivered via a flexible monofiber quartz lightguide with 400-μ luminiferous filament through the cannula. The power at the end of the lightguide was controlled with an IMO-2 device before and after the exposure. After laser destruction of the adenohypophysis, the cannula was removed and the wound in the soft palate was sutured layer-by-layer. Negligible bleeding after drilling in the main bone usually ceased after laser exposure. The animals were sacrificed 1-90 days after surgery by intrapulmonary injection of sodium thiopental (1 g). After opening the skull, the material was collected in a block including the basal bone with the adjacent pituitary and hypothalamus in the sagittal plane from the crossing of optic nerves to the brain stem.

RESULTS

One day after HILE, the anteroinferior surface of the pituitary in the preparations looked grayish-brown with a central 2-mm black spot, corresponding to the projection of the lightquide outlet on the basal bone. A hemispheric grayish-brown zone of laser destruction of the adenohypophysis was seen on sagittal section, the base of this hemisphere was directed to the radiation source and occupied the entire thickness of this part of adenohypophysis. The same zone of destruction in biological tissues after Nd:YAG exposure was described by other authors [3,9]. The dura mater of the basal bone around the operation opening was encircled with a 2-mm grayish-brown rim.

Two zones were seen on histological preparations of the adenohypophysis collected 1 day after HILE: necrotic and perifocal with preserved pituitary structure. The necrotic zone had sites of fine granular oxyphilic mother with fragments of nuclei and chaotic accumulations of ball-shaped glandular cells (anuclear or with small pyknotic nuclei). Microcirculatory disorders were seen: small focal hemorrhages, capillary stasis and thrombosis, and tissue loosening (edema). There were neutrophilic granulocytes, macrophages, and fibroblasts among dead parenchymatous cells. No changes were detected in the neurohypophysis and hypothalamic zone of the brain. We observed no cavities and vacuolated layer caused evaporation of interstitial fluid, described by some authors [1,7]. The absence of such changes can be due to low power and short exposure accompanied by warming of tissues and protein denaturing, but not evaporation of interstitial fluid.

Three days after HILE the focus of hemispheric coagulation necrosis was 5×4×3 mm in size with clear-cut borders and remained grayish-brown. The size, color, and consistence of foci of lesions in the pituitary membranes did not change. Islets of granulation tissue containing newly formed capillaries, fibroblasts, macrophages, individual granulocytes, and a fine network of fucsinophilic fibers were seen in damaged zones.

Ten days after laser exposure the anteroinferior surface of the pituitary grew into the dura mater of sella turcica fossa. These connections corresponded to the zone of operative opening in the basal bone and did not involve the meninges and adjacent vessels. The pineal body decreased by 1-2 mm due to shrinkage of the adenohypophysis. The focus of necrotic detritus was surrounded by granulation tissue shaft, containing macrophages, fibroblasts, and forming capillaries; there were only individual neutrophilic granulocytes. Intact fragments of the adenohypophysis at the periphery of the focus were divided into lobules by granulation tissue; the trabecular structure was impaired. In addition, there were individual glandular cells with pyknotic nuclei and fucsinophilic fibers.

Microscopic analysis of alteration foci in the adenohypophysis showed poorly expressed neutrophilic granulocytic infiltration at all terms, which was in line with other reports [4,6]. This phenomenon is usually attributed to a decrease in bacterial contamination due to specific bactericidal effect of HILE and to the absence of vasoactive mediators in the foci [7] playing an important role in the development of exudative inflammatory reaction [2].

One month after laser destruction of the adenohypophysis, the content of fibroblasts in the focus decreased, vessels gradually reduced, while fibrillar structures predominated. These changes were paralleled by fibrous cicatricial transformation of the granulation tissue in the focus. At the same time the size of the pituitary decreased due to cicatrization of PA after its laser destruction, which corresponded to previously described wound contraction [14]. Fibrosing processes in the focus of alteration with regression of the majority of capillaries took 2 months.

After 3 months, granulation tissue transformed into the adenohypophysis cicatrix. The focus of lesions in membranes was local and its size did not exceed 5×4 mm; time course of changes in the focus corresponded to morphological changes in the focus of adenohypophysis destruction described previously. The cicatricial adhesive process at the final stage of reparative regeneration was confined to the sella turcica cavity and did not involve the meninges and adjacent vessels of the skull base.

The results of experimental morphological study enabled us to develop and patent a method for treatment of PA, which was used in the treatment of 87 patients (24 men and 63 women) aged 16-55 years in our hospital. The tumor was diagnosed on the basis of clinical and laboratory data and magnetic resonance findings. Hormonally inactive PA were diagnosed in 38 cases and hormonally active in 49 (32 of these produced somatotropic hormone and 17 prolactin and manifested by acromegalia and prolactinemia, respectively). Patients most often complained of incessant headaches and decreased visual fields; conservative therapy was ineffective. Laser destruction of PA through a transnasosphenoid access under narcosis was performed in all patients. Under x-ray control in the direct and lateral projections, a metal cannula with a perforator was inserted into the median nasal passage and passed through the anterior wall of the sphenoid sinus towards the anteroinferior compartments of the sella turcica in a patient lying supine. Puncture of the sella turcica was easy due to thinning of the bone tissue. After removal of the perforator from the cannula, a monofiber quartz lightguide was inserted and the tumor was irradiated with Nd:YAG laser (power and duration of exposure the same as in the experiment). Then the cannula was removed and a hemostatic sponge impregnated with canamicin solution was inserted into the sphenoid sinus for 24 h. The operation was well tolerated due to low traumatism. After 2 weeks headaches ceased and visual fields extended; no nasal liquorrhea or hypothermia were recorded. HILE caused no complications in the adjacent brain structures and vascular wall.

Hence, the proposed method for surgical treatment of PA is effective, safe, and atraumatic.

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