REVIEW

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Use of Laser Technologies in Oncourology

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Abstract

Due to the increasing use of laser technologies in oncourology, we consider it relevant to publish a review of domestic and foreign articles for 2015-2021. The range of application of various lasers in oncourology is very wide (holmium (Ho): YAG, thulium (Tm): YAG, etc.). In comparison with traditional surgical interventions, the greatest effectiveness of laser technologies in combination with endoscopy is clearly traced, the risks of intra – and postoperative complications are minimized, the period of inpatient stay for patients changes.

Keywords

Oncology, Urology, Laser, Holmium laser (Ho): YAG, Thulium laser (Tm): YAG

Imprint

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Introduction

Since the middle of the XX century, the era of an introduction and a wide use of laser technologies in medicine began. 1960 has offered the greatest scientific discovery: the world's first laser [1]. The scope of the first application of the lasers in urology and oncology included lithotripsy and laser bladder surgery [2, 3]. The morphology and histology of laser-exposed tissues was first described by Staehler et al. in 1976. The laser in surgery of the 80s already demonstrated many "points of application" [4, 5]. The pioneering resection of prostate adenoma was performed with laser in 1986 [6] and found its broad application since 1990 [7]. The evolution of laser technologies and the accumulation of experience in their use in medicine gave an impetus to the development of a large number of types of lasers [8]: KTP (potassium titaniyl phosphate, KTP: Nd: YAG); LBO (lithium borate, LBO: Nd: YAG); diode laser; holmium lasers (Ho): YAG (with aluminoy yttrium garnet); thulium lasers (Tm): YAG.

The aim of our reference literature review is to analyze and compare the different types of lasers used in the treatment of urology and onco-pathologies.

Benign hyperplasia and malignant tumors of the prostate

Among the various lasers, with a wavelength approximately of 2 μm, the most effective are found those with crystalline media based on aluminum yttrium garnet activated by chromium, holmium and tullium ions. It has been just the holmium that laser in the fifteen-year period, since 2002, has been massively introduced in use in urology and uro-oncology in the Russian Federation [15]. In the process of refining of urological endoscopic techniques, it has been detected that with a laser pulse, water quickly evaporates directly at the distal end of the optical fiber, which is characterized by the absence of heating and burning of the fiber tip. In this case, 20% of the energy is consumed for water evaporation, and the rest thereof can be successfully used for the purpose of surgery. A tissue dissection is performed with a contact-type technique, and coagulation is provided in a contact-free way. The radiation of this laser mainly evaporates blood, and upon the exposure thereof the blood vessels can be twisted without noticeable formation of blood clots that reduces the probability of a secondary bleeding due to their mechanical disintegration [15]. With the use of this technique providing an interaction of laser with the tissues of the posterior urethra and the ablation of prostate tissues, scarring is practically avoided during the healing of a laser wound [14]. The microscopy examination of histological samples, 7 days after exposure to a holmium laser with an energy density of 310 and 530 J/cm^2, has revealed moderate edema associated with some hemorrhage fields, mixed inflammatory cell infiltration in the region of coagulation necrosis [13]. The areas of the prostate close to the region of coagulation necrosis are expanded prostatic ducts partially filled with

protein-eosinophilic secretion products and zones of necrotic epithelial cells thoughout the entire depth of the cut. The interstitial stroma, between the expanded ducts and the glands, is characterized by moderate swelling with multifocal mononuclear infiltration. By week 3 (after exposure to the holmium laser), the area of the crater-type destruction is covered with epithelium consisting of 2–6 layers thereof. In the tissue areas close to the laser cut, infiltrates from inflammatory cells, neutrophils, lymphocytes and macrophages are determined throughout the depth of the produced cut. In the same areas noted are the glands overfilled with cellular detritus, with obliterated ducts. 5 weeks after the completed laser destruction, the exposed areas are covered with normal transitional cell epithelium. Morphological changes of this sort has not initiated the cicatricial process [3, 12]. With the beginning of the use of the thulium laser (Tm): YAG (2017), the negative effects of the holmium laser, i.e. the damaging effect made by the shock wave on the soft tissues, the retropulsion (practically the absence thereof) of the stone during fragmentation, the use in practice of only rigid technique, have been eliminated.

Surgeons have faced the problem of false negative results in the diagnostics of prostate cancer after transurethral laser enucleation (laser destruction of the edges of resection). This problem was often discussed by foreign researchers in publications released in 2017-18. The main difficulty in the diagnostics of prostate cancer in the study of histological material is the damaging effect of the laser and the impossibility of objective histological verification of tissues of the resection margins [9]. It should also be noted that the diagnostic value of transurethral interventions for the detection of malignant prostate lesions is low. In order to verify the diagnosis in patients with a high risk of prostate cancer, it is advisable to perform a preliminary transrectal multifocal prostate biopsy [16]. Laser ablation/resection of the prostate in cancer is not an effective or safe alternative to radical prostatectomy.

Malignant tumors in the urinary system

The laser technique has shown its good performance and applicability particularly in the treatment of urothelial carcinomas. In 2017 (Huazhong University of Science and Technology, Wuhan, China, Department of Urology of Tongji Clinic), a comparison of the effectiveness and feasibility of laser enucleation of a bladder tumor with transurethral resection was published in 13 studies [10]: 1037 patients underwent transurethral resection of prostate (TURP), and 975 underwent transurethral laser enucleation. According to database studies available before 01.2017 (PubMed, Wed of Science, Google scholar and Medline, EMBASE), there were no significant differences in the surgery time between the two groups, although laser enucleation was superior to the TURP in bladder perforation, in the catheterization time, in the reduction of the obturator nerve block reflex, hospitalization time and the recurrence rate per annum. A more accurate result of histological studies of the removed tissue during laser resection is noted [10]. In 2018, the AMC University Clinic (Amsterdam, the Netherlands), Prof. O. Lodeizen, has published data on the treatment of patients with prostate cancer with focal laser ablation [2]. Her report has highlighted the difficulty of using the laser ablation accompanied by extremely high cost of equipment and the lack of advantages in comparison with conventional radiation treatment methods.

Experts of the Spanish University Hospital named after J. M. Morales Meseguer, Murcia, presented their experience of outpatient treatment of recurrent bladder cancer by transurethral laser fulguration followed by outpatient MMC (mitomycin-C instillation [11]. This technique is considered to be a real and safe alternative to transurethral resection of the bladder.

Conclusions

Laser technologies, almost everywhere, have become an integral part of medical practice throughout the world. They have found their application in the treatment of urolithiasis, benign prostatic hyperplasia, oncopathology and scarring of the urinary system. When using a laser in performing a surgical intervention, it is noted the following:

– the surgery time is reduced;

– the number of bleedings, intra - and postoperative complications decreases;

– there is no damaging effect made by the shock wave on the tissue in the application area available;

– it is possible to use various in instrumentation considering its calibration and rigidity (flexibility in use).

The practice of using conventional surgical instruments is inferior in efficiency to methods of laser technologies in endoscopy and laparoscopy. Perhaps, in the near future, these newer technologies will successfully compete with radical resection surgery in tumor disease treatment and urological pathology.

Statement on ethical issues

Research involving people and/or animals is in full compliance with current national and international ethical standards.

Conflict of interest

None declared.

Author contributions

The authors read the ICMJE criteria for authorship and approved the final manuscript.

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