Lasers in Modern Medicine

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It is not an exaggeration to state that no single high-tech system has recently opened such profoundly new possibilities in medicine as the laser. Our own 18 years of using laser technology experimentally and clinically have led to a number of standard procedures and revealed new aspects for future investigation.

Laser Application

The versatility of laser applications is astonishing. The product of energy density and application time leads to a variety of interactions with tissue, some of which have become standard procedures in therapy; others are being used experimentally in therapeutic or diagnostic approaches. Photon energy, expressed in the wavelength of a laser, also plays an important role in these interactions (Fig. 1).

All possible laser-tissue interactions are of relevance in medicine, from low-power tissue irradiation, producing biological effects by energy densities well below the threshold for thermal interaction, over thermal interactions, to high-power effects.

Photodynamic Therapy

The most promising use of the laser is in photodynamic therapy (Fig. 2). The fairly old principle of activating a photosensitizing agent by light has been developed into a therapeutic concept using high-power light sources such as the argon-ion Laser or the argon pumped-dye laser.

Integral photodynamic therapy is a concept adapted to the multifocal nature of superficial cancer. While patients are being treated worldwide with hematoporphyrin derivatives (HPD), photosensitizing agents with less toxic side effects have been sought and are currently being tested.

The field of low-power irradiation has also given rise to investigations that have deepened our understanding of the elementary laser-tissue interactions, such as mitosis synchronization and biochemical stimulation. The combination of both might enhance chemotherapeutic efficiency. Our group has tested a similar concept of adding phototoxic processes to cyto-statics, which may possibly increase the efficacy of adjuvant chemotherapy while reducing the side effects.

Thermotherapy

Clinical data on thermal interactions caused by higher power densities in

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seconds or minutes are abundant. The conversion of electromagnetic radiation into heat increases the tissue temperature and leads to protein denaturation at temperatures over 60°C and to vaporization and ablation at temperatures over 100°C.

Our group experimented with tumor destruction from 1972 to 1976 [4]. To date, we have treated more than 1500 patients with superficial and infiltrating bladder carcinoma using the Nd:YAG laser. With this mode of treatment the local recurrence rate has dropped remarkably compared with that following transurethral resection. This is presumably connected with the total, contact-free destruction of the tumor-bearing area of the vesical wall by the simultaneous sealing of blood and lymphatic vessels. Apart from this, the absence of bleeding provides an excellent view during coagulation and aids therapy when multifocal tumor growth is present. Randomized studies on laser treatment of bladder carcinoma by Beisland, Meier et al., and Le Guillou et al. [1, 5, 7] verify the remarkably low recurrence rate after Nd:YAG laser therapy. Conservative, organ-saving therapy of superficial urothelial cancer of the upper urinary tract using the Nd:YAG laser is very promising; clinical application, however, should be restricted to specialized centers until enough clinical data are available to prove its superiority to other treatments.

**Fig. 1.** Energy density-time diagram as expression of laser-tissue interaction