The Use of Contact Laser in Neurosurgery. Clinical and Experimental Data

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Introduction

Recent technological improvements have resulted in the introduction of contact probes which have improved laser fiberoptic delivery system and substances able to transmit laser light. The sapphire tips introduced by Daikuzono and Joffe in 1985 [1] are currently used to deliver more than 90% of laser light, causing no tissue adhesion phenomena. This is an artificial crystal which is hard enough and has enough mechanical resistance to prevent breaking of the tip. Lateral irradiation, which results in 30–40% of the total power delivered in non-contact probes, is avoided, thus providing substantial reduction in laser energy requirements. The contact tips are so efficient that very low thermal energy is required for a sharp incision, because of such rapid tissue vaporization. The greater divergence of the beam limits the thermal effect, thereby minimizing the lesion. The contact probes are suitable for both freehand and endoscopic application.

Instrumentation

Contact laser systems can be adapted to non-contact laser systems. However, it must be pointed out that stability in delivery of low power energy is required to avoid melting of the sapphire tip. The sapphire connection with the optic fiber is easily carried out simply confronting the two surfaces. A cooling system avoids tip overheating and assures the removal of smoke and gases produced by tissue burning.

Two sets of probes are available; one for cutting and one for hemostasis. Diameter of the distal end of the tip accounts for the diameter of the beam at the target and as a general rule the thinner probes require lower energy settings to achieve corresponding tissue effects. Hemostatic efficiency is higher with the larger sapphires. The incisional capability depends on the laser power input and the diameter of the probes. The following probes
are currently used. 1) Sapphires with a 0.2 up to 1.2 mm diameter and with 9 up to 19 mm length. The larger tips are used for dissection in cavities; 2) A sapphire with a 0.05 mm diameter which is employed in microsurgery. There is a frosty surface sapphire which delivers energy from the tip and lateral surface that is also used in highly vascularized tissues.

Laser sources used in contact delivery systems are Nd: YAG and argon. Neodymium: YAG is a solid state laser, made from a crystal yttrium aluminum Garnet with incorporated (ion doped) Nd$^{3+}$ of certain concentrations; these ions are excited by the absorption of light energy. The beam is emitted on a near infrared range with a wavelength of 1.06 microns. Guide beam is a coaxial 2 w He-Neon laser.

Argon is an ion-gas laser. Excitation is obtained by producing an electrical discharge at a very high current density in ionized gas. The beam is visible, ranging in the blue-green part of the spectrum with a wavelength of 488–514 nm. More than 70% of the energy is selectively absorbed by hemoglobin. Transmission is through fiberoptics. When used at non-contact, backwards and forwards scattering are evident in both lasers, incision being wide and faintly wedgeshaped. Hemostasis is sufficient for veins and arteries up to 1 mm.

The KTP/532 laser is a pure green laser wavelength of 532 nm, produced by a potassium titanyl phosphate crystal. Theoretically due to the higher absorption of red oxygenated hemoglobin by the green light (about 95%) hemostasis is enhanced. However, penetration depth is influenced by chromophore density, i.e., tissue vascularity. This wavelength cuts, coagulates and vaporizes more efficiently, with less carbonization and smoke than with CO$_2$. The surgical system is a frequency-doubled Nd: YAG laser by

Fig. 1. Bipolar forceps. Prototype (a) optic fiber, (b) sapphires