Experimental Studies of Photodynamic Therapy Using Pulse Laser

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Introduction

CW lasers, such as Nd:YAG laser, Argon laser and Argon pumped Dye laser, are widely utilized for the purpose of medical treatments. On the other hand, pulse lasers are not so popular as CW lasers due to their unstabilities, operative complexities and sometimes difficulties of coupling into a single optical fiber.

In order to evaluate the availability of pulse laser in the photodynamic therapy, the distribution of the power density in mice tumors, the damage of a quartz plate and the efficiency of the tumor destruction were studied.

Materials and Methods

Quanta-Ray DCR-2A-10 Nd:YAG laser and Quanta-Ray PDL-1 Dye laser were used. The laser pulses had a duration of ca.5 nsec. and a repetition rate of 10pps. The peak intensity was $1\text{MW}/\text{cm}^2$ at average intensity of $50\text{mW}/\text{cm}^2$.

The 635nm beam of 1mm diameter was irradiated on the surface of C3H/He mouse tumor MH-134. The lateral scattering of freshly cut surface of tumor was measured by a photomultiplier and a Box-Car integrator.

Nd:YAG laser (532nm) beam was focused into a quartz plate of 1.5mm thickness by a convex lens of $f=30\text{mm}$, in order to determine the maximum peak power for their coupling to a single quartz optical fiber. The damage of a quartz plate was examined by a stereoscopic microscope.

C3H/He mice with subcutaneous MH-134 tumors were given 5mg/kg HpD i.p.. After 24 hours, tumors were irradiated through the skin by CW or pulse laser for 20min. The efficiency of the tumor destruction was evaluated by the histological examination.

Results and Discussions

The power density of lateral scattering induced by pulse laser showed an exponential decrease with increasing depth and reduced to

1/100 at approximately 6 to 7.5mm depth, which is similar to that of CW laser. There is no difference in light propagation in mice tumor between CW laser and pulse laser, since the depth of light penetration into tissue is dependent on the wavelength of light(Fig.1).

The beam, focused on laser delivering side of the quartz plate, made a small crack at peak power of over $100\text{kW}/\text{cm}^2$, however no crack was observed at peak power of under $78\text{kW}/\text{cm}^2$. When pulse laser beam is focused into a single quartz fiber, the permissive maximum peak power will be $100\text{kW}/\text{cm}^2$. The beam, focused near the lens apart from the quartz plate, could not easily make a crack.(Fig.2)

At equivalent total light energy, partially deeper necrosis was observed in the case of CW lasers than that of pulse lasers(Table 1).

Conclusion

From these studies,² it is concluded that pulse laser light with intensity of $100\text{kW}/\text{cm}^2$ of peak power can be introduced to a single quartz fiber without a crack. Pulse laser was found not always more effective on photodynamic therapy than CW laser.

Fig. 1 Lateral scattering of tumor

Fig. 2 Damage of quartz plate

Case No.	Laser	Average Power	Tumor	Necrosis Necrobiosis
1	CW	$35\text{mW}/\text{cm}^2$		+
2				++
3				±
4	Pulse	$35\text{mW}/\text{cm}^2$		+
5				++
6				±
7	CW	$70\text{mW}/\text{cm}^2$		++
8				+++
9				++
10	Pulse	$70\text{mW}/\text{cm}^2$		++
11				+
12				+
13	CW	$95\text{mW}/\text{cm}^2$		+++
14				+++
15				+++
16	Pulse	$95\text{mW}/\text{cm}^2$		++
17				++
18				+++

Table 1 Histological result