IRRADIANCE ATTACHMENT FOR AN OPTICAL FIBER TO PROVIDE A UNIFORM LEVEL OF ILLUMINATION ACROSS A PLANE

TECHNICAL FIELD

The present invention relates to photodynamic therapy methods and devices. More particularly, the present invention is directed to devices which provide and deliver a highly uniform irradiation beam which is particularly suitable for photodynamic therapy.

BACKGROUND ART

Photodynamic therapy (PDT) exploits the selective uptake of a photosensitizer in tumors and other hyperproliferative target tissues. Since the difference between target tissue uptake of photosensitizer and that of normal tissue is at best only marginal, uniform delivery of light is crucial to attain optimal photodynamic effect. Some degree of selectively may be achieved by simply aiming the light beam at the desired target tissue, but to truly offer selectively of action on target tissue versus adjacent or intermixed normal tissue, selective uptake of dye into target tissue and uniform delivery of light is required. Variations in applied light intensity may result in certain areas within a treatment field receiving over or under dosing. Thus, tumor tissue may be inadvertently spared destruction if present in an area of under treatment, while normal tissue may be destroyed if light intensity is focally increased in a certain area.

Clinical applications of PDT have used free optical fibers as well as diffusing lenses to administer laser light to treatment areas. Light delivery is usually accomplished with an argon-pumped dye laser using a single wavelength of light. This allows for easy calculation of delivered light dose and an estimate of photodynamic effect.

The selective uptake of dihematoporphyrum ether (DHE) and other photosensitizers within tumors, or other rapidly proliferating tissues, is the basis for most of the therapeutic benefit of PDT. Although photodynamic effect may be directed to specific areas by selective placement of the treatment beam, this affords little benefit in treating most diseases over other descriptive modalities. Selective destruction of target tissue over adjacent, or even intermixed, normal tissue depends upon selective uptake of photosensitizer in target tissue as compared to normal tissue. This has been shown to occur with numerous tumors and other proliferative disorders in vivo, with a variety of photosensitizers. Relative differences in the uptake of DHE into target tissue versus skin, have been shown to be 1.08, 1.8, 2.2, 3.9 and 4.2 in various animal models. Although newer photosensitizers such as the phthalocyanines and 5-ALA-induced protoporphyrin IX may result in even higher relative differences in photosensitizer uptake in target tissue, normal tissues still retain significant amount of photosensitizer in most cases.

Tissue DHE content is a function of the administered DHE and its degree of retention within various tissues. Because differences between target tissue DHE content and normal structures is relative and not absolute, uniform light delivery is imperative to ensure destruction of tumors while sparing normal healthy tissue.

DISCLOSURE OF THE INVENTION

It is accordingly one object of the present invention to provide device for producing and delivering a highly uniform irradiation beam of light.

Another object of the present invention is to provide a light delivery device which is particularly useful for photodynamic therapy.

It is a further object of the present invention to provide a device which produces a beam of light which has a highly uniform illumination throughout the entire field thereof.

A further object of the present invention is to produce a photodynamic light delivery device which can be in direct contact with a target situs during use.

A still further object of the present invention is to provide a method of photodynamic therapy wherein a light delivery device which produces a highly uniform beam of light is in direct contact with a target situs during use.

According to these and further objects of the present invention which will become apparent as the description thereof proceeds, the present invention provides a light delivery device which includes:

- a hollow spherical shell which defines a cavity therein and includes a diffusive reflective inner surface;
- an input aperture formed within the hollow spherical shell for passing a beam of light into the cavity;
- a diffusive reflective surface within the cavity which is supported away from the inner surface of the hollow spherical shell and aligned with the input aperture, whereby light which passes through the input aperture into the cavity is reflected off the diffusive reflective surface before reaching the diffusive reflective inner surface of the spherical shell; and
- an output aperture formed within the hollow spherical shell through which only light that is reflected off the diffusive reflective inner surface exits the hollow spherical shell.

The present invention further provides a method of applying photodynamic therapy to a target situs which involves:

a) providing light delivery device, the light delivery device including:
   - a hollow spherical shell which defines a cavity therein and includes a diffusive reflective inner surface,
   - an input aperture formed within the hollow spherical shell for passing a beam of light into the cavity,
   - a diffusive reflective surface within the cavity which is supported away from the inner surface of the hollow spherical shell and aligned with the input aperture, whereby light which passes through the input aperture into the cavity is reflected off the diffusive reflective surface before reaching the diffusive reflective inner surface of the spherical shell, and
   - an output aperture formed within the hollow spherical shell through which only light that is reflected off the diffusive reflective inner surface exits the hollow spherical shell;

b) positioning the output aperture of the light delivery device near a target situs; and

c) delivering light into the light delivery device and therethrough to the target situs.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will be described with reference to the attached drawings which are given by way of non-limiting examples only, in which:

FIG. 1*a* is a schematic diagram of an integrating sphere according to the present invention.