FACULTY OF MEDICINE
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Diode Laser in Ophthalmic practice

ESSAY

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بسم الله الرحمن الرحيم

قال الله تعالى

وقل اعملوا فسيرى الله عملكم ورسوله والمؤمنون

صدق الله العظيم

بسم الله الرحمن الرحيم

To my

Parents

My wife

My daughter LINA

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all The praise is due to ***ALLAH,*** who wanted life for this work, I, would like to express my deepest gratitude and appreciation to proffessor ***Dr. NEGM EL-DIN HELAL*** for his continuous support, kindness and humanity .

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Introduction and Historical Aspects of Laser Applications in Ophthalmology

Therapeutic retinal Photocoagulation has been practiced over the past 40 years. Initial experiments were carried out in the *1940s by Meyer Schwickerath.* The initial studies used focused sunlight. But the introduction of the xenon arc photocoagulation in 1956 provided both a more reliable and more controlled source of intense light.

In 1960, the first working laser was constructed by Maiman, using a ruby crystal, the ruby laser with monochromatic emission of Red Light (694.3 nm) was used during the early 1960's to a great number of retinal conditions. However, although it was found to be acceptable in producing chorioretinal adhesions for treating full-thickness retinal breaks, it was less successful in the treatment of proliferative diabetic retinopathy.

This lack of success of the ruby laser in treating retinal vascular conditons was originally attributed to the inability of red light to be absorbed within the haemoglobin in retinal capillaries, Beetham et al. 1969.

More recent studies on the biophysics of beam-tissue interactions now indicate that the wave-length of the emitted light was not of prime importance but that the pulse duration of the early ruby systems was too short to initiate an adequate photocoagulation without the risk of heamorrhage, the increasing risk of heamorrhage with decreasing pulse duration is now well established and is known to be related to the spead at which tissues are converted into gas. (Singerman., 1982).

To some extent the intial misconceptions concerning the relative importance of wavelength, led to the development of the blue-green continuous wave (CW) argon laser photocoagulation by L'esperance. This became commercially available in 1971 and was in widespread clinical use by 1975.

One of the complications of using argon blue-green lasers for treating macular conditions arised because of the presence of the yellow luteal pigment within the inner neuronal layers of the central retina. The early argon photocoagulator emitted more than 70% of its radiation in the blue spectrum (488 nm) and this was close to the peak absorption of the luteal pigment (460 nm). Early treatment with such systems resulted in non therapeutic damage to the inner retinal layers and a resultant loss of vision. (Smiddy et al. 1984)

More recently this problem has been addressed in two ways. First, by the production of a new generation of argon lasers in which the blue emission is two ways. First, by the production of a new generation of argon lasers in which the blue emission is precluded from entering the eye by specialized optics within the laser and Second by the advent of a red liaht emitting laser, the krypton laser.(L'esperance, 1969)

Although, the clinical use fulness of both gas and liquid state continuous wave lasers has been established, there are a number of disadvantages of such systems, which include the high costs of purchase and maintanance, their size, their high power consumption and the necessity for the cooling facilities to dissipate the heat that they generate.

Recent developments in solid state electronics have enabled the production of coherent radiation by semiconductor crystals called semiconductor diode laser. This infrared laser, is now commercially available with output power levels up to one watt. This development was predicted by Pratesi in 1984, who also realized the potential clinical value of such devices. The latter auther in collaboration with ***Brancato*** Inflicted the first diode-induced lesions in rabbit retina, and they described their histology.

The lesions produced were discribed as being similar to those produced by current clinical laser Brancato and Pratesi, 1987.

Comporable results have been obtained with semiconductor endophotocoagulation of rabbit retina. The study was performed by ***Puliafito and her***

Co-workers in (1987).

Brancato and Pratesi (1988), were the first who used phtocoagulation by diode laser on rabbit retina from a slit lamp. In the same year McHugh et al., (1988) used infrared diode laser in photocoagulation of a number of rabbits and human eyes. They throwed also a spot light on the effect of diode laser in comparison with argon and krypton lasers.

In ***1989, McHugh*** carried out apilot study to investigate the clinical use of an infrared diode laser, in the treatment of a number of retinal vascular conditions.

Hitzenberger, and Fercher (1989) discovered a new method for determining the axial length of the human eye. This method is based on laser interferometry with partially coherent light emitted by semiconductor laser diode.

Today diode laser is used in treatment of many ophthalmological problems as proliferative diabetic retinopathy, diabetic maculopathy, branch and central retinal vein occlusion and open angle gluacoma.

The potential low price of these systems which do not need an external water cooling supply and high power electrical source, will allow even economically underdeveloped countries to benifit from this new advanced medical technology.

Principles of laser and modes of operation

Principles of Laser and Modes of Operations

According L'esperance

In a quiescent state a collection of atoms or molecules will predominatly populate the lowest energy level, since this level is the only stable one. More accurately, the population of the levels depends on the temprature of the material. If the temprature is sufficiently high, significant numbers of molecules will be found in upper levels. The distribution of atoms in these levels is discribed as Boltzmann's distribution in which a higher energy level always has fewer atoms populating it than a lower level.

Virtually all atoms or molecules are in the ground state. Thus if a light beam of the correct wave-length is introduced into the medium, the beam will be attenuated because atoms will absorb photons of the beam and be excited to an upper level, from which they will, for the most part, spontaneously emit photons in random directions and return to the ground state.

A condition is achieved with more atoms in an excited state than in a lower state or the ground state. If a beam of light was introduced, the beam would be amplified as the excited atoms would be stimulated to emit photons in phase and coherent with the exciting light beam. This is called stimulated emission.

The basic requirements for attaining laser operation are now apparent, First, a population inversion must be obtained; that is, more atoms must be placed in an upper or excited state than in a lower state. Second, a light beam of the correct wavelength must be introduced to stimulate the excited atom into emitting light coherent with the exciting light beam.

There is a number of methods, that have been used to obtain population inversion; one of these methods used to provide radiation of the proper wavelength is to place the laser medium in an optical cavity that acts as a resonator (Fig.2.1). The resonant cavity consists of two mirrors carefully aligned to each other; the laser material (gas, solid state) is placed between them. One of the mirrors is made partially transmitting so that some of the radiation will be coupled out of the cavity.

Once population inversion has been achieved, the laser radiation produced begins with some of the excited atoms in the medium emitting spontaneous radiation in various random directions. Some of the radiation, however, will hit one of the mirrors and return, passing through the medium. This radiation that is re-entering is exactly the correct wavelength (Since the material it-self radiated it) and will therefore stimulate some of the atoms into emitting radiation, thus amplifying the beam. After the wave bounces back from the other mirror, it will be ampli-

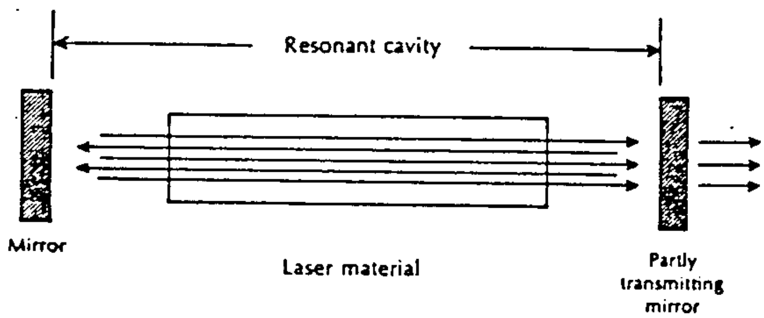

Fig.(2.1) Typical laser cavity showing the laser material, the totally reflecting mirror and the partly transmitting mirror that allows a portion of the resonting beam to escape from the cavity.

(quoted from L'esperance, 1989)