LASER IN GENERAL SURGERY

ESSAY

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Master Degree in General Surgery

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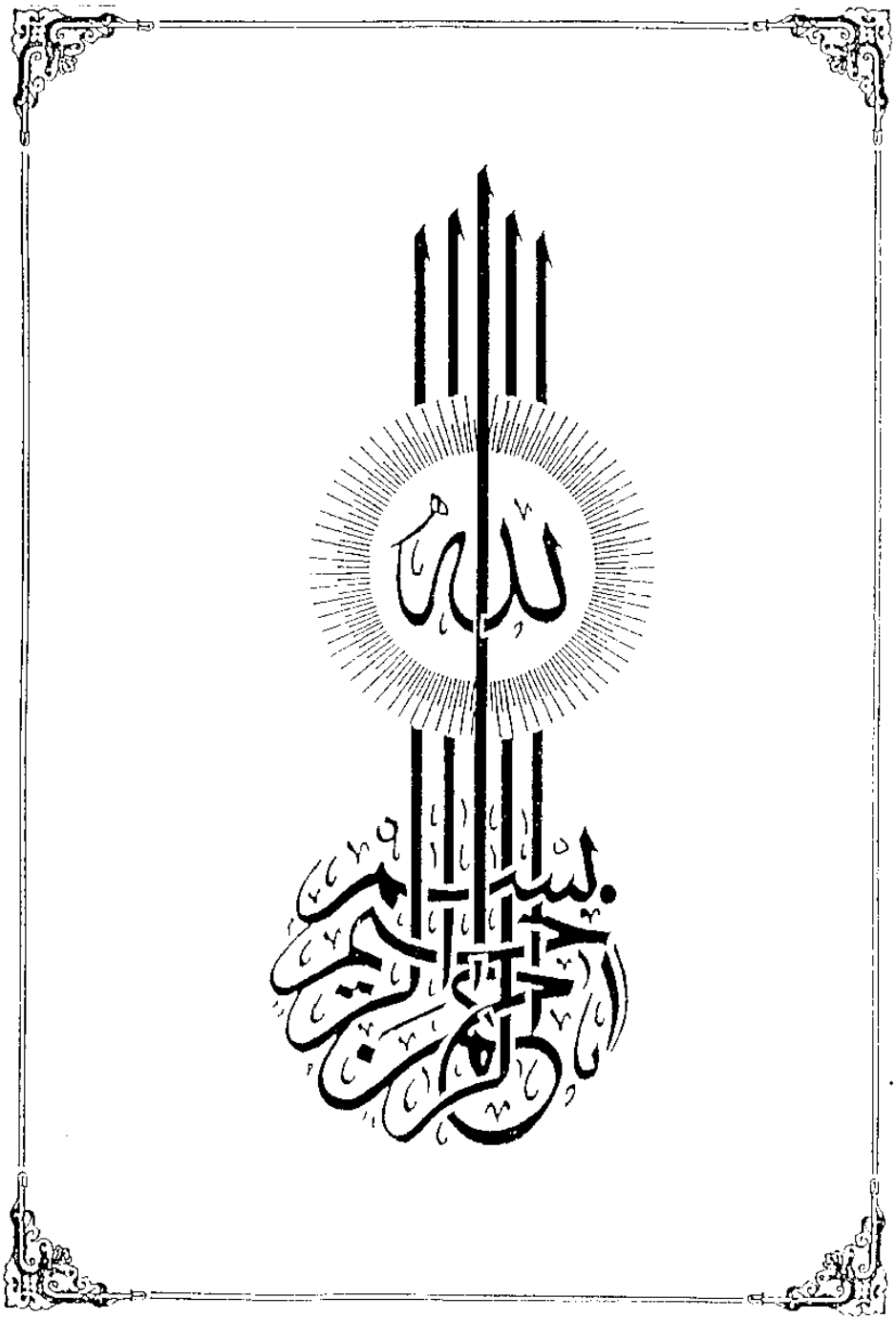

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بسم الله الرحمن الرحيم

« سبحانك لا علم لنا إلا ما علمتنا

إنك أنت العليم الحكيم »

صدق الله العظيم

(سورة البقرة الآية ٣٢)

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Introduction

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INTRODUCTION

Laser is a light energy which is a part of the electromagnetic wave spectrum.

The word laser is an acronym for Light Amplification by Stimulated Emission of Radiation.

Since the production of the first laser beam which is based on a ruby crystal, devised by Maiman, in 1960, laser has been used in many medical and surgical branches as general surgery, ophthalmology, gastroenterology, gynecology and in cardiovascular surgery. In 1964, Gordon et al. devised the Argon, Krypton and Xenon Lasers while Patel introduced the CO_2 laser in 1965. This laser was soon adapted by Polanyi for use in cutting applications in 1968, but actual significant development occurred when Nath perfected the coupling of laser source to optical fibers, thus opening the way for laser energy to be directed into the body through endoscopes (*Choy*, 1988).

The clinical benefits of using laser in surgery are easily assessed and widely accepted. Yet, the effects of laser energy on tissue structures are complex and partially understood (*Colles*, 1988).

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There are various types of laser and all named after their lasing media, and they include Ruby laser, carbon dioxide (CO_2) laser, Helium-neon laser, Argon laser, Neodymium-Yettriu aluminium garnet laser (Nd:YAG), and dye laser (*Cortese,* 1986).

A laser like any surgical instrument, must be used with skill and common sense (*Stein,* 1986).

The purpose of this study is describing this relatively new equipment, its role in general surgery will be our main objective.

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Laser Physics and Types

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LASER PHYSICS AND TYPES

Laser Physics

Light interacts with atoms in three distinct ways (Fig. 1).

I. Absorption

The atom absorbs light energy and is elevated to a higher energy state.

II. Spontaneous Emission

An atom in the excited state, in returning to its stable resting state, releases light energy.

III. Stimulated Emission

An atom in the excited state is impacted by light of specific wavelength. In returning to the resting state, the atom is stimulated to emit a greater quantity of light energy, with the same wavelength. This mode of interaction is the basis for laser light production (*Minton*, 1986).

Theoretically, laser can be produced from any matter whether it is solid, liquid or gas.

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Laser beam can travel long distance unless absorbed, and can be reflected, reflacted or focused (*Minton,* 1986).

The Basic Structure of Laser System

The laser system consists of four principal parts: (Fig. 2)

I. The Active Medium

There are many kinds of laser media such as: CO_2, He-Ne, Argon (gas or ion), Nd:YAG, Glass, Ruby, Dye solution.

II. The Means of Exciting the Active Medium into its Amplifying State

Solid state lasers such as Nd:YAG are excited by flooding the material with light from an intense lamp. This energy is absorbed and pumps the lasing ions (Nd^{3+} in this case) into an inverted state. In gaseous lasers (i.e.: the CO_2 laser) the excitation is produced by running a proper electric discharge through the medium (*Bass,* 1986).

III. The Feedback Device

It consists of a resonant cavity, in which the laser medium is located and two reflector mirrors at each end of the active medium, one of the two mirrors is partially reflecting, the other is completely

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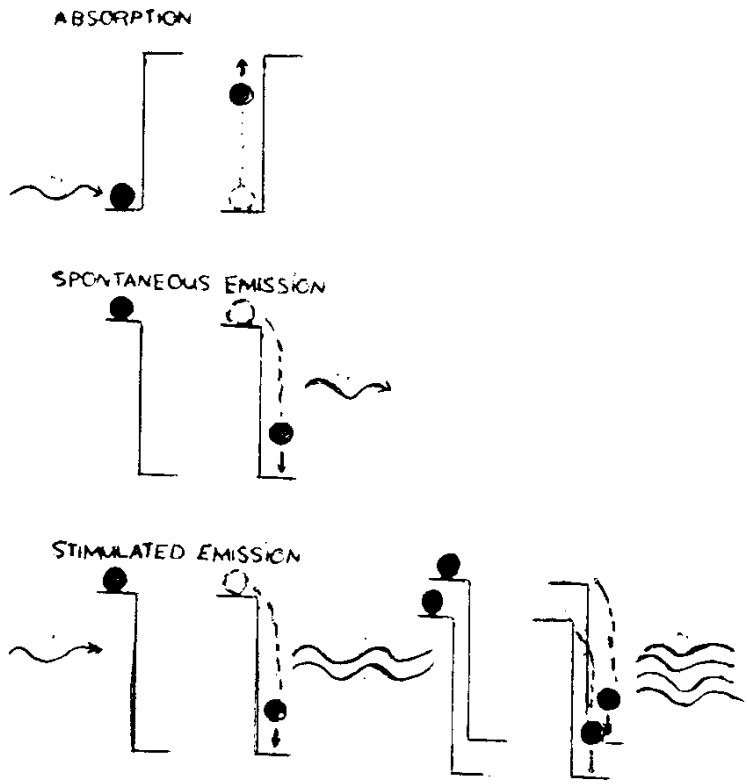

Fig. (1): Showing the three radiative processes that are involved in laser action: Absorption, spontaneous emission, stimulated emission (*Hermens et al.*, 1983).

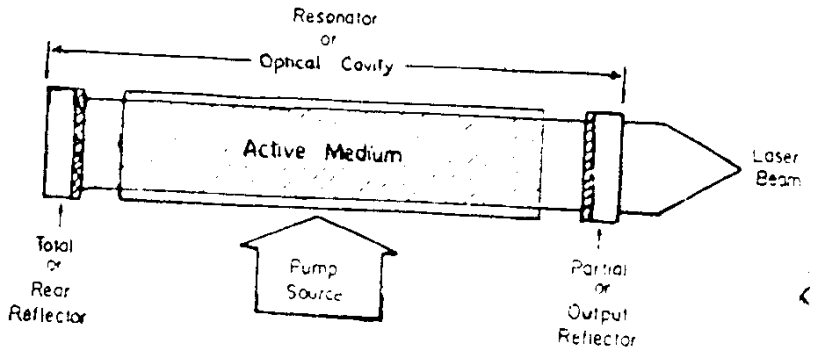

Fig. (2): Basic components of laser system (*Fuller*, 1984).

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reflecting, thus permitting a fraction of the photons of light to escape out of the cavity.

VI. The Cooling System

Some of the laser energy is lost as heat. Thus, most laser systems require some mechanisms to remove the heat, such as water or air cooling (*Stein,* 1986).

The laser delivery system is gained with a shutter mechanism to control the process of delivering laser beam which may be delivered as continuous (CW) wave (the beam continues to be emitted at a steady rate for as long as the surgeon needs) or as pulsed wave (a stream of impulses separated by intervals of time) or as superpulsed laser (short impulses with high peak power of energy) (Fig. 3) (*Billie,* 1988).

This super-pulsed laser or the Q-switched mode, is characteristic by extremely high power (megawatts) with very short time (nsec). This laser results in a laser with minimal thermal damage (*Stein,* 1986).

Power Density of Laser Beam

Power density is defined as output power divided by spot size, i.e.:

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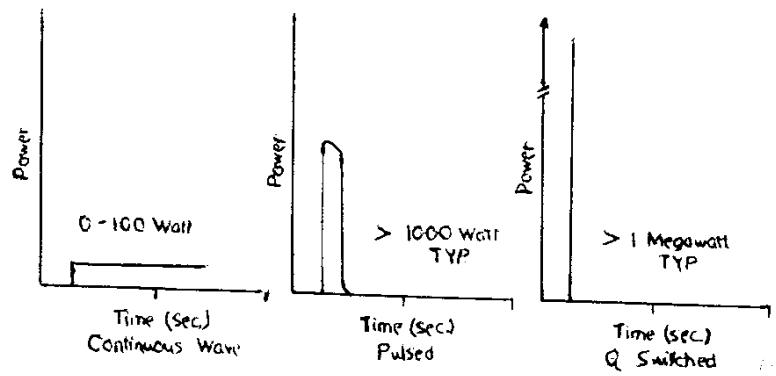

Fig. (3): Mode of laser delivery: continuous, pulsed and Q-switched waves (*Billie,* 1988).

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Power Density = Power (watts) per unit area (cm^2).

So, the smaller the spot size, the higher the power density. Such changes determine the depth of penetration of laser beam (*Bass*, 1986).

Exposure Time

It is the time or duration of exposure of the tissue to the laser emission. The exposure time is controlled by a shutter system that can rapidly turn the laser beam on and off. This permits a precise dose of energy to be delivered to the tissue (*Billie*, 1988).

Types of Laser Used in Surgery

There are numerous types of lasers in use in medicine. Lasers may be classified according to their active media into solid, liquid or gaseous lasers (Fig. 4) (*Saliney and Wolbarsht*, 1980).

I. Solid State Lasers

A. Ruby Laser

This is the first laser known. Ruby was the active medium. It has wavelength of 694 (nm) and is absorbed by melanin. It is used in treating skin lesions such as naevi (*Cochrane*, 1986).

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