RECENT DEVELOPMENTS IN SURGERY: LASER

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Laser is one of the few recent developments in surgery that need clear understanding not only by the medical students and professionals but also by the public at large which constitutes the subject of surgery.

Laser, first successfully developed by Americans in 1960 is an acronym that stands for Light Amplification by Stimulated Emission of Radiation[1]. Lasers utilize high energy waves within the electromagnetic spectrum to produce heat for the surgical effects of cutting, ablation (vaporization) and coagulation[2]. Lasers work on the principle of Radiation Heat Transfer, i.e., the laser beams contain no inherent heat and the electrodes of "bovie" units are not hot. They both transmit radiation energy. Heat is created only when the tissue absorbs the transmitted radiation and converts it to motion in its atoms and molecules. This is exactly the way a microwave oven works only at different frequencies.

Light (photons of energy) is contained within the forces that hold together atoms and molecules. By tapping into these atomic and molecular bonds, we can release the light that is stored there. Regular light sources such as light bulbs release this light energy in a random, chaotic type process of spontaneously emitting the light. Photons of all energies (wavelengths or colours) are released in all directions with no coordination between them. This results in incoherent white light (all colours combined radiating in all directions). However, laser light consists of the same photons of light as in ordinary light sources but releases them in an organised fashion. Lasers convert electrical energy to photons by directing electrical current into the lasing medium or into a bright lamp (flash lamp/pumping lamp). When a photon from the flash lamp strikes an electron within the lasing medium, the electron is excited to a higher energy state by the absorption of energy. The electron rapidly returns to its resting state, releasing the absorbed energy as a photon characteristic of the lasing medium. This process is known as "spontaneous emission." If this photon strikes an electron already excited to a higher energy state, its return to the resting state is accompanied by the release of an extra identical photon of the same wavelength and with wavefronts synchronized (in phase) with each other. This process is called "stimulated emission." These two photons strike two more excited electrons, and the process multiplies exponentially as the photons are "amplified" between two mirrors. Laser light is monochromatic (of a single wavelength and hence, of one colour or atleast pure colours) and that wavelength is determined by the lasing medium and the laser is named after the material used. It is termed "coherent light" as all the photons are in phase with each other across time and space. All photons of laser light traverse in one direction as a tight beam "(collimated)'. Finally, laser light is a very intense beam of bright light. For the first time, a laser beam was produced by exciting the molecules of a ruby crystal (Fig. I). Subsequently, dyes, gases (commonly $C0_2$) and various rare elements like Neodymium were used instead of a ruby crystal to produce a laser beam.

Indiviudal lasers differ considerably in their effects on biological systems and therefore, no single laser is suitable for all purposes. Five common medical lasers are the carbon dioxide ($C0_2$). Neodymium : Yttrium Aluminium - Garnet (Nd: YAG), Potasium Titanyl Phosphate(KTP) and Holium: Yttrium - Aluminium - Garnet (Ho: YAG) and Argon (Table - I).

Several parameters control the delivery of the laser energy to the tissue. These include the power (watts), total energy delivered (watts and

1. Radiation here does not refer to such ionizing type radiations as X - Ray. It refers to a "radiant" body or one that "shines" light.
2. Some laser modalities use effects other than generating heat for specialised applications not included in general surgical techniques.

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time), power density (how small is the focussed spot used to intensify the light), the colour of the light, and the colour and vascularity of the tissue.

Surgical lasers have evolved into two broad basic mechanisms - free beam and contact applications. "Contact" lasers encompass the popular sapphire probe and the sculptured fibre devices. Laser light transmits through these fibres and sapphire devices but the major mechanism of action is conduction heating from the crystal material to the tissue directly through contact. The "Free Beam" lasers rely on the radiation transfer and absorption by the tissue to create their heating effects. This may be delivered by a straight beam, such as a CO_2 laser, or by any of the fibre - optic lasers such as Nd: YAG, Argon, KTP or Ho : YAG.

Apart from its increasing role in diagnosis [trace element analysis in metabolic studies and toxicology, laser flourescence in localising early lung cancer and atheromatous plaques before vascular surgery, three dimensional photography (holography) of internal organs through fibre-optic endoscope and measure of capillary blood flow by doppler effect, etc] and phototherapy by the hastening of the photochemical process [neonatal jaundice, cancer, various skin disorders (psoralen therapy)], laser has established its definite role in conducting the surgical procedures. When a laser beam is focussed on a tissue, an intense and localised heating results, leading to tissue damage which is proportional to the intensity of the beam used. Such photodestructrion occurs in an absolutely aseptic environment as no physical contact is involved. This is now commonly used in treatment of retinal detachment and proliferative diabetic retinopathy by photo-coagulation.

A laser beam can be accurately focussed on a small spot of the order of a few micrometers. Now it is possible to open up the blocked canals of Schlem while treating glaucoma, to allow alteration of the structure of an organelle or even a chromosome and to introduce a new gene through a submicron hole drilled in the cell membrane microsurgery at subcellular level, opening a whole new area of genetic engineering.

As laser can travel through fibre optic system and laser knife reduces blood loss, fibre optic endoscopic laser surgery is becoming increasingly common in treatment of gastro-intestinal lesions. It is associated with less postoperative pains. Laser angioplasty is done alone or in combination with balloon angioplasty. Cosmetic surgery for the facial wrinkles etc. is being evaluated.

Owing to the utmost precision and interaction with biological systems, the many fascinating and rapidly developing applications are sure to become more deverse in the near future - endoscopic laser therapy of oesophagogastric lesions, colorectal carcinoma, laser photodynamic therapy of solid tumours, liver resection, biliary laser lithotrispy, laparascopic laser surgery, laser haemorrhoidectomy, laser vascular surgery etc.

Although lasers were developed 40 years ago, they have become a more common fixture in the operating room only in the last decade. Lasers are very effective, but are more expensive, require additional specialized training, are slower and cumbersome to use. Safety measures, particularly eyewear, must be employed. Their chief advantages are their precision and predictability. their use may become more popular as welding anastomoses and joining tissue becomes feasible.

TABLE - I

COMMON MEDICAL LASERS

Laser	Colour	Wavelength
Argon	. Blue	488 nm
	. Green	515 nm
KTP	Green	532 nm
Nd : YAG	Near Infrared	1064 nm
Ho : YAG	Mid - Infrared	2100 nm
CO_2	Far Infrared	10600 nm

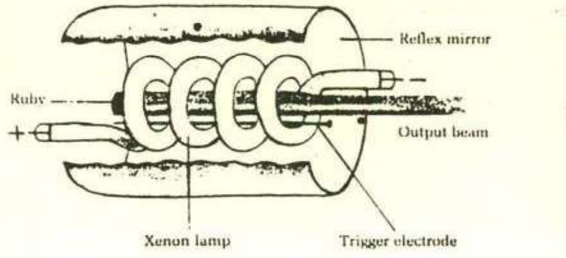

Fig. I Mechanism of Ruby Laser Production.