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# A Study on Laser Techniques Utilization at Medical Level

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## ABSTRACT

In contemporary medicines, which progressively consumed for treatment of multiplicity of pathologies as notice in less invasion treatment modalities intensifies? The physics after lasers allows the plain principles to be applied to a mass of tissue types using minor modifications of the system. Multiple laser systems have been measured within each area of medicine. The term “laser” was joined with “surgery”, “ablation”, “lithotripsy”, “cancer treatment”, “tumor ablation”, “dermatology”, “skin rejuvenation”, “lipolysis”, “cardiology”, “atrial fibrillation (AF)”, and “epilepsy” during separate searches in the PubMed database. Original articles that studies the use of laser energy for these conditions studied and involved. A review of laser therapy is available. [1]Laser energy can be securely and successfully use for lithotripsy, as for the numerous treatments of numerous types of cancer, for a multitude of cosmetic and reconstructive procedures, and for the ablation of irregular conductive pathways. For each of these conditions, managing with laser is comparable to, and potentially greater to, management with more customary methods.

**KEYWORDS**: Laser, Laser lithotripsy, Laser therapy, Laser treatment

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## INTRODUCTION

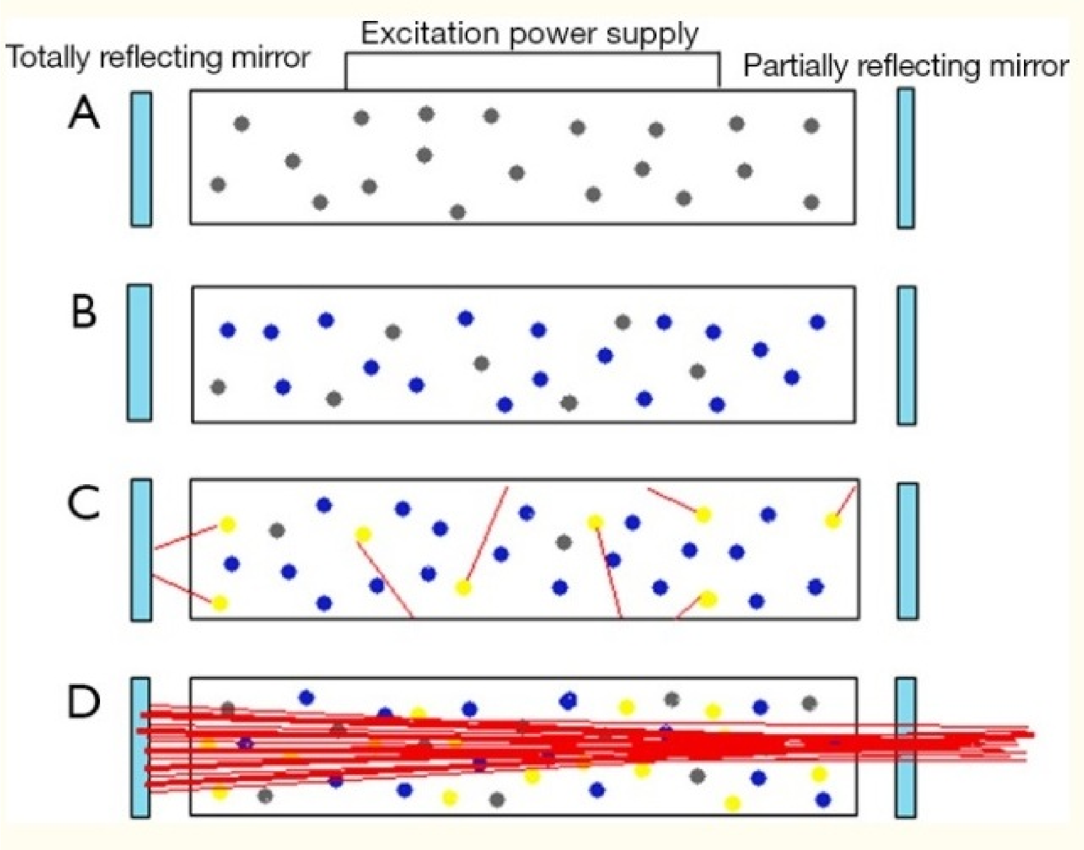
In 1900, Max Planck learned that the light is released, transferred and engrossed in specific amounts of energy which is called quanta, and that was connected to the frequency of the radiation and what he discovered was to be Planck's constant. Shortly after that, Einstein printed his work on quantum theory, in which he stated that most atoms exist in the ground-energy state (E0). These E0 molecules which then can be transformed to higher energy levels when energy is added to them, and in returning to their ground state, the energy is released impulsively as photons or electromagnetic (Em) waves. He also discovered that when a photon of the same wavelength collides with an excited atom, the two photons, which released are concomitantly and therefore, would have equal frequencies. This idea of "stimulated emission" years later was used in the creation of lasers.[2,3]

Theodore Maimaneventually created the first "laser" (light amplification by stimulated emission of radiation) by using an electrical source to energize a solid ruby. Following this notated invention, its several possible indications in medicine were quickly recognized. As the CO2 laser known was to emit a concentrated ray of light that was effortlessly absorbed by water, it became used to vaporize tissue. The neodymium: yttrium-aluminum-garnet (Nd:YAG) laser formed coagulative necrosis within tissue, and the visible light laser were beneficial for achieving homeostasis. Over time, numerous different active media have been used to create new lasers, resulting in their usefulness in a wide range of medical subspecialties. [4]The goal of this review is to deliver an overview of the physics behind laser systems, representing how the same basic principles can be applied to various tissues type to accomplish the desired effect, and how this has led to wide range of clinical applications of laser.

## EXPERIMENTAL DESIGN OF LASER PHYSICS

A simple laser consists of a laser medium (which determines the wavelength of the system) bounded between two parallel mirrors, one of which is partly reflecting and partially transmitting. An electrical source excites the medium until the number of atoms in the excited state is greater than the number on the ground state (population inversion). When the laser medium is in activated state, it begins to release excited photons impulsively in every direction. However, a small subset of these photons moves along the centerline of the laser system in joined between the mirrors. The mirrors then reflect these photons and the process of stimulated emission isthen improved. The moderately transmitting mirror then allows a powerful, cohesive beam of photons that are released as laser light (5).

**Figure (1) : Demonstrates a laser medium at ground state (A) followed by excitation of atoms to higher energy levels (B) and progression to stimulated emission (C) with laser beam generation as final product (D).** [5]




## EXPERIMENTAL DESIGN OF LASER-TISSUE INTERACTION

The effect that a laser has on a section of tissue is reliant on both properties of the tissue as well as the laser. The tissue properties contain its structure, water content, thermal conductivity, heat capacity, density, and its capability to absorb, scatter, or reflect the produced energy. The properties of the laser that play a role are its power, density, energy content, and wavelength.

The main biological targets that dealt with absorb light very differently, and their optimum absorption spectra be contingent on the wavelength of the incident photon energy. For the visible light and about near-infrared lasers, the key target chromophores (any substance that absorbs light) are hemoglobin and melanin, whereas for CO2 lasers, the only chromophore is water. In order to attain selective photo thermolysis (using energy at high peak powers and short pulse widths to abolish the intended target alone) without being destructive to the nearby tissue, the target tissue must contain chromophores that engross a specific laser wavelength, and these chromophores should not be found in the surrounding tissue. [6,9]

The CO2, Nd: YAG and argon lasers are the lasers most usually used in medicine and surgery. The CO2 laser has carbon dioxide gas as its medium and emits energy at 10,600 nm. Because its chromophore, water, exists everywhere, CO2 lasers cannot be used for selective photothermolysis, though they are tissue-selective. All of the incident energy is absorbed in the tissue water down to a specific depth, preventing deeper tissue damage. CO2 lasers operate in the unseen infrared waveband, thus requiringappointing beam for precisetreatment. Focusing the laser on the tissue produces tremendously high power density resulting in immediate vaporization and ablation of the tissue. As the irradiance of the laser beam is relative to the inverse of the square of the diameter of the beam, by defocusing the beam, the surgeon is able to simplyalterthe laser from incision mode to bulk vaporization or coagulation. The CO2 laser has a number of beam modes, each of which responds differently with the tissue. The simplest mode is continuous wave (c=CW), in which the laser beam is produced, operated for a specific time, and then turned off. More current lasers however are quasi-CW (ultra pulsing), meaning they produce short high-peak power pulses with are very long inter-pulse intervals. This has the advantage of permitting more precise incisions with minimal heal build-up because each pulse that is brought is shorter than the time it takes the targeted tissue to cool.

The active medium of the Nd:YAG laser is a single YAG crystal bar enclosed with neodymium ions. The wavelength of light that is formed by this system, which determined by the neodymium ions, is Nd: YAF laser-tissue collaboration produces largely a scattering effect. Scattering leads to reflection, which stops the typical narrow, cohesive beam from being produced. [7]This decreases the penetrative ability of the laser, resulting in slower heating of the tissue. This property of the Nd: YAG laser makes it model for homeostasis and tumor necrosis, as well as various endoscopic procedures within various specialties.

Ions lasers, such as the argon and krypton lasers, function similarly to gas lasers, except ionize active medium. This excites ions instead of atoms, using a huge power supply. They can work at both pulsed and CW modes and can produce wavelengths anywhere between 250 and 530 nm, with the two most powerful beams being in the blue (488 nm) and green (514.5 nm) ranges of the spectrum.

## EXPERIMENTAL DESIGN OF LITHOTRIPSY

Laser lithotripsy has been an extensively acknowledged technique for the fragmentation of urinary and biliary stones for the past few decades. Lasers can achieve lithotripsy by having a photo acoustical/photomechanical effect (laser-induced shockwave lithotripsy) or a predominantly phototherapy effect. [8] Of the laser normally used in lithotripsy, the 1-µsec pulsed-dye laser is the most popular shockwave laser and has been widely studies. This device is based on the excitation of coumarin dye to produce the monochromatic light that fragments the calculi. At 504 nm, a green light that is captivated mainly by the yellow-colored urinary calculi is produced, which allows it to be securely used without causing much harm to surrounding tissues. As the stone absorbs the energy from the laser, the excited ions that are released from a rapid expanding and pulsating cloud around the stone, generating a shock wave that then breaks the calculus into fragments. Because this laser is vain against the nonabsorbent colorless calculi such as those composed of cysteine, photosensitizers (dye) have used successfully as irrigation fluids and absorbents to initiate the process of fragmentation. The Q-Switched Nd: YAG laser also accomplishes lithotripsy by this mechanism, but it creates larger-magnitude of shockwaves.

The long-pulsed Holium: YAG laser on the other hand, uses a mostly photo thermal mechanism to fragment calculi. The laser produces light with a wavelength of 2,100 nm, which is extremely absorbable by water. Thus in the suitable environment, fluid absorbs the energy and is heated as a result. A cloud of vapor is produced, parting the water and allowing the lasting portion of the laser light to straight contact the calculus surface, drilling holes into it and leading to its fragmentation. A study which was conducted by Cimino et al. demonstrated that Ho: YAG laser lithotripsy is more efficacious endoscopic technique for the treatment of ureteral stones with higher stone fragmentation rates than compared to pneumatic lithotripsy, and a review conducted by Teichman concludes that this laser is harmless, real and works just as fine if not better than other modalities, and that, it may also be used for biliary stones.[10]

**Figure (2a): demonstrates a Ho:YAG lithotripsy laser (A) and an neodymium;yttrium-aluminum-garnet (Nd:YAG) dermatologic laser (B).**

## EXPERIMENTAL DESIGN OF ONCOLOGY

Lasers currently used are safe for the treatment of cancers rising in numerous organ systems. In neurosurgery for example, laser interstitial thermal therapy (LITT) is a favored treatment option for patients who are not perfect surgical candidates. Since their introduction to neurosurgery, laser have become progressively safe to use and have been effectively applied for the treatment of unresectable gliomas well as hard and hemorrhagic tumors such as meniniomas, tumors of the deep skull base , or tumors deep in the ventricles. Mucosal ablation methods using lasers are at present being extensively and positively used for the treatment using lasers are now of superficial gastrointestinal cancers including early gastric cancer, superficial esophageal cancer, colorectal adenoma, and high-grade Barrett's esophagus. [11]Moreover, photodynamic therapy (PDT) using lasers have shown been to be an effective treatment modality for specific types of lung cancer lesions.

Direct laser ablation has been used for direct obliteration of cancer cells through its photochemical, photomechanical, and photo thermal effects. The photochemical reactions that occur eventually from toxic radicals that lead to the death of tissues, the photomechanical reactions induce stress on the tissue and lead to its fragmentation and the photo thermal reactions persuade heating and coagulation, which cause cell death.

To improve this process and more precisely target the desired tumor cells, PDT established was nearly a century ago has gained great popularity ever since. This treatment modality involves the administration of a photosensitizing drug followed by the subsequent illumination of the target area with visible light equivalent to the absorbance wavelength of the photosensitizing drug. The photosensitizer, which then activated, originally forms the excited singlet state and then transitions to the triplet state, which in the presence of oxygen from reactive oxygen species that are critical to neoplastic cells. Selective photo thermal therapy, on the other hand used localized light-absorbing dye to enhance the laser-induced demolition of the tumor cells.

## RESULT ON AESTHETIC AND RECONSTRUCTIVE SURGERY

The exceptional ability of laser to target specific structures and layer of tissue makes them an influential tool in cosmetic and reconstructive surgery. Laser resurfacing has been a major tool used for anti-ageing treatment in modern medicine, as the induction of new collagen formation known is to lessen the effects of photo aging. Original skin resurfacing techniques involved using ablative CO2 and Re:YAG laser systems to target a specific portion of the dermis. However, because these systems also eliminate a significant amount of epidermis, they result in lengthy recovery and amplified side effects such as infections and erythema. Nonablative lasers, suchas the intense pulsed light, Nd:YAG, diode, and Er:glass lasers, which habituallyrelease infrared light, were subsequently advanced to overcome their issues. [12]The goal of these systems is to mark the water in the dermis, which during the process hears collagen and induces remodeling. Because there is a system that at the same time cools the epidermis, tissue evaporation does not cover and no external wound produced.In recent times, fractionated laser resurfacing has become the basic skin resurfacing. Using fractionated laser, fine bean of high-energy light are used to inducing small zones of thermaldamage ("microscopic thermal zones") and treating only fractions of skin at a time.

Laser-assisted lipolysis, which uses an optical figure introduced inside a 1-mm cannula, has also become amore and more popular procedure in cosmetic surgery. Due to the small cannula size, a smaller incision needed is, resulting in few bleeding and scar formation. Of all the lasers that are accessible for medical purposes, those with 920 nm wavelength have the minimum absorption coefficient in fat tissue, and so they infiltrate the deeper layer of tissue. Those with wavelengths in the 1,320-1,444 nm range have the major absorption coefficient in fate, causing minor penetration depth and allowing for superficial treatment of such tissues. The Nd:YAG laser (1,064 nm) is the system that is used most widely in laser lipolysis, as the absorption coefficient of fat tissue in this wavelength result in good penetration depth with medium absorption, causing only modest temperature elevation and thus less tissue destruction. Further, the coagulation of small blood vessels by the laser light at this wavelength results in considerably less blood loss during the procedure. Abdelaal and Aboelatta were able to show a significant drop in blood loss (54%) with laser-assisted liposuction when compared to traditional methods. Additionally, a review conducted by Mordon and Plot concluded that laser lipolysis produces additional even skin results.

Finally, the ability of lasers to selectively target pathologic vasculature makes them an ideal source for the treatment of vascular defects such as port-wine stains. Before use of lasers, patients did not have many treatment options for these types of abnormalities. Currently however, laser that are preferentially absorbed by hemoglobin over melanin are used for this purpose, with little trauma to the epidermis.[12] More lately, lasers with longer wavelengths, and thus the skill to achieve deeper tissue penetration, have been presented.

## DISCUSSION IN CONCERN TO ABLATION OF CONDUCTIVE PATHWAYS

After it was discovered that the pulmonary vein (PV) are an significant source of ectopic beats that lead to the paroxysms of atrial fibrillation (AF), the growth of catheter ablation devices was inspired for circumferential PV isolation (PVI). Today, the laser balloon catheter is one of the endoscopic ablation systems (EAS) usually used for the treatment of AF. The device contains a catheter with a complaint balloon at its tip that is repeatedly flushed with deuterium oxide. The catheter introduced is into the left atrium and an endoscope then is inserted into catheter shaft, allowing direct picturing of the ablation target inside the heart. Ablation is done with a 980-nm diode laser that is housed in the central lumen, emitting laser energy perpendicular to the catheter shaft covering an arc of a 30˚ angle and permitting circular ablation around each PV. Laser at this wavelength is not engaged by deuterium oxide.

As a result, it enters tissue beyond the endothelium, where water molecules, resulting in heating and coagulation necrosis, absorb it. The energy that delivered can be titrated by changing the power (5.5-12 W) in a set of predefined levels. The energy levels are changed depending on which cardiac wall is being targeted. The Nd:YAG laser is another laser system that is usually used for this purpose. A multicenter study led by Metzner et al. has shown noteworthy success rates of PVI using EAS, and has suggested that the 1-year success rate is similar to conventional PVI techniques (about 63%).[13,14]

In order for successful result in a complete conducted block, fully transmural lesion must be created in the heart. Melby et al. established that electrical impulses, both paced and AF, could till propagate even through very thin gaps (≥1 mm) in the ablation line. When associating the effects of different energy levels, studies have shown that the use of higher energy levels results in higher rates of PVI with lower AF recurrence rates and no negotiation of the safety profile.

In neurological surgery, MRI – Guided laser persuaded thermal therapy (MRgLITT) frequently used to treat refractory epilepsy, either as a means of ablating the epileptic foci, or as a stoppage tool. MRgLITT combines a diode laser (980-nm) with picturing technology to provide intra operative information that is essential for controlling the amount of energy conveyed.

A review conducted by Bandt et al. demonstrated the positive use of laser ablation for the management of refractory epilepsy of many different focal origins including mesial temporal lobe epilepsy, cortical dysplasia, post-stroke neocortical focus, encephalocele, periventricular nodular heterotopia, and hypothalamic hamartomas. In addition to individual techniques for epilepsy management, there are disconnected treatment strategies that separate the epileptogenic brain from the non-epileptogenic brain by corpus callosotomy or hemispheretomy. Calistro et al. demonstrated successful endoscopic disconnection of hypothalamic hamartomas with the use of a robot-assisted thulium-laser and Choudhri et al. positively demonstrated the use of a carbon dioxide laser for corpus colostomy in children.

## CONCLUSION

Since their development, the use of lasers in treatment has become extremely widespread and often vital. From life-threatening diseases to psychologically stressful cosmetic defects, laser therapy has led to advancements in countless pathologies, ultimately promoting both patients and physicians. [15] The evolution of laser technology thus far has led to the practice of marginally invasive procedures, petite recovery times, and less risk to patient health. As laser technology remains to improve in precision and safety, their applications in treatment are sure to expand to continue providing harmless outcomes, best clearance of disease and better patient satisfaction.

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