Benedito Rodrigues da Silva Neto
(Organizador)

Alicerces e Adversidades das Ciências da Saúde no Brasil 4

Atena Editora
Ano 2019

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2019

2019 *by Atena Editora*

Editora Chefe: Profª Drª Antonella Carvalho de Oliveira
Diagramação: Natália Sandrini
Edição de Arte: Lorena Prestes
Revisão: Os Autores

Atena Editora
Ano 2019

Dados Internacionais de Catalogação na Publicação (CIP)
(eDOC BRASIL, Belo Horizonte/MG)

A398 Alicerces e adversidades das ciências da saúde no Brasil 4 [recurso eletrônico] / Organizador Benedito Rodrigues da Silva Neto. – Ponta Grossa, PR: Atena Editora, 2019. – (Alicerces e Adversidades das Ciências da Saúde no Brasil; v. 4)

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
ISBN 978-85-7247-673-7
DOI 10.22533/at.ed.737190210

1. Ciências da saúde – Pesquisa – Brasil. 2. Saúde – Brasil. I.Silva Neto, Benedito Rodrigues da. II. Série.

CDD 362.1

Elaborado por Maurício Amormino Júnior – CRB6/2422

Atena Editora
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Atena Editora
Ano 2019

APRESENTAÇÃO

A coleção “Alicerces e Adversidades das Ciências da Saúde no Brasil” é uma obra composta de cinco volumes que tem como foco as bases e as interfaces multidisciplinares dos trabalhos desenvolvidos em diversos locais do país que compõe os diversos capítulos de cada volume. De forma categorizada os trabalhos, pesquisas, relatos de casos e revisões tentarão demonstrar ao leitor os princípios de cada área da saúde assim como suas peculiaridades.

Apresentamos aqui o quarto e último volume desta obra tão relevante e interessante para todos aqueles que se interessam pelos atuais alicerces aos quais as ciências da saúde tem se sustentado no Brasil. Diversos eixos foram abordados nos volumes anteriores, e complementando este volume final trás consigo temas como Hanseníase, Neurogênese, Políticas públicas. Saúde, Continuidade da Assistência ao Paciente, Câncer Ginecológico, Filariose Síndrome de Meigs, Glioma, proteômica do câncer, Bioética, Alocação de recursos para atenção em saúde, Trauma de membros inferiores, Infecções Bacterianas, Doenças Negligenciadas, Carcinoma hepatocelular, Hepatite, Triatomineos, Vigilância Entomológica, Biomarcadores, Sistema Internacional de Estadiamento e Metodologias ativas.

A fundamentação, e o estabelecimento de conceitos e padrões básicos é muito importante na ciências da saúde uma vez que novos estudos e pesquisas tanto de revisão quanto experimentais sempre se baseiam em técnicas e fontes já publicadas. Assim, destacamos a relevância deste material com informações recentes sobre diversas temáticas da saúde.

Portanto a obra “Alicerces e Adversidades das Ciências da Saúde no Brasil 2” oferece ao leitor teoria bem fundamentada aliada à resultados práticos obtidos pelos diversos grupos de pesquisa em saúde do país, que arduamente desenvolveram seus trabalhos aqui apresentados de maneira concisa e didática. A divulgação científica de qualidade, em tempos de fontes não confiáveis de informação, é extremamente importante. Por isso evidenciamos também a estrutura da Atena Editora capaz de oferecer uma plataforma consolidada e confiável para estes pesquisadores apresentarem e divulguem seus resultados.

Desejamos à todos uma excelente leitura!

Benedito Rodrigues da Silva Neto

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CO_2 LASER IN CARDIOLOGY FOR REVASCULARIZATION

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ABSTRACT: Laser device emits laser by optical amplification which is based on simulated emission of electromagnetic radiation. Earlier a CO_2 laser with 450W power was used for the creation of channels in heart vessels. Currently CO_2 laser having wavelength of 10,600 nm with energy level of 15-20 joules per pulse and pulse duration of 25-40ms are being used. TMLR is a technique in which small 20-30 channels of size 1mm are drilled in left ventricle and heart muscle by CO_2 gas laser for better perfusion of blood. Laser is applied on heart vessels by a device named laser gun. Trans-myocardial revascularization by CO_2 laser is a revolution in cardiology. It is an alternative to open heart surgery, applied on the patients of refractory angina who are not able to be treated by conventional methods.

KEYWORDS: CO_2 Laser,

1 I INTRODUCTION

A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. The term “laser” originated as an acronym for “Light Amplification by Stimulated Emission of Radiation”. A laser is created when the electrons in atoms in special glasses, crystals, or gases absorb energy from an

electrical current or another laser and become “excited.” First, its light contains only one wavelength.

Robert von Lieben and Lee de Forest in 1905/06 invented vacuum amplifier. Which were later improved up to millimeter wave region. Electromagnetic waves in optical frequency range were generated by the means of thermal radiation till 1950. Optical coherent waves were only generated by Laser. Gordon, Townes and Zeiger in 1954 invented MASER which was the first amplifier based on discrete energy levels. The first laser made by solid-state material Ruby was invented by Maiman. The very first gas laser that was invented was He-Ne laser which was basically a gas laser which was built by Ali javan at MIT. The wavelength of this laser was 628.8 nm and its line width was only 10 kHz. An optical resonator laser contains partially reflecting mirrors which cause internal losses. These losses are compensated by a gain media which is fitted inside the resonator.

MEDIUM USED FOR LASER: First of all we will discuss different types of media like gas, liquid and solid-state which are used for making lasers. Laser gain media are the media which are used for making laser since there are 3 types of lasers so the gain media can be solid, liquid and gas. However there are few parameters which are responsible for the conversion of media these are upper state lifetime, $\tau_L = T_1$,line wdith $\Delta f_{FWHM} = 2/\underline{T_2}$ and the cross-section for stimulated emission. Lasers are classified into 4 types based on the type of laser medium used: i)Solid state laser ii) Gas laser iii)Liquid laser iv)Semiconductor laser Here we will discuss only Gas Laser.

GAS LASER: A device which is able to produce coherent electromagnetic radiation whose wavelengths are shorter then microwave frequencies. Usually a gas laser contains atoms or molecules of a gas which are excited to higher energy states. Shortly a gas laser consist of a gaseous medium which is in excited state by the help of electric energy and all this is enclosed in a closed optical path to keep optical energy for long time. Gas laser was the first technology in which electrical energy was used to produce lasers. Gas lasers are the lasers in which coherent light is produced by passing electric current from a gas. Gas lasers are the first continuous-light laser. And these are the first lasers which work on the principle of converting electrical energy to the laser energy as an output.

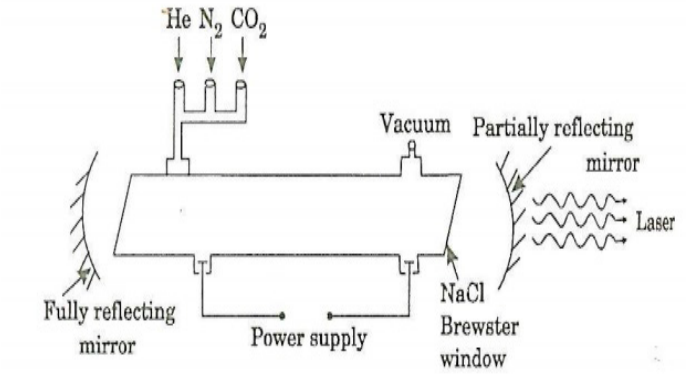


Figure: Layout of Carbon dioxide laser

Lasers are of different types based on the medium. The laser medium can be a solid, gas, liquid or semiconductor. Lasers are commonly designated by the type of lasing material employed: Solid-state lasers have lasing material distributed in a solid matrix (such as the ruby or neodymium: yttrium-aluminum garnet “Yag” lasers).

GAS LASER TYPES: Gas lasers are of different types: they are: i) Helium (He) ii) Neon (Ne) iii) Argon ion lasers iv) Carbon dioxide lasers (CO_2 laser)

HELIUM-NEON LASER: He-Ne is the most famous noble gas laser. Lasers of different wavelengths like 543.5nm, 593.9nm, 611.8nm, 1.1523µm etc. can be achieved through this. In this type of laser gain media consist of two gases Helium and Neon. The mixture ratio is of the range of 5:1 to 20:1 with low pressure. Transfer of energy done by the collision of excited He atoms with grount state Neon atoms. The excited Neon atom can relax to ground state by spontaneous and stimulated emission of a photon. The strongest transitions are at 1.5 _m and 3.39 _m. In the visible, transitions at 543.5 nm (green, measured in vacuum), 594 nm (yellow) and 612 nm (orange) exists. The typical red laser uses the transition at 632.8 nm(measured in air).

Electrical discharge is used for excitation of Helium atoms in Helium-Neon laser. The collisions between helium and neon atoms cause the population inversion between Neon energy states. The collision between the atoms of these two gases is called second kind of collision. When energy of a metastable state of a gas lies very close to the excited energy state of other gas atoms. A pure mixture of Helium and Neon gas is the basic need for the operation of a He-Ne laser. As we know that the gas filled in laser is of the range of 1 torr wich is not significant and can escape very quickly by a small leakage from outside. To overcome this problem a device is used which is called getter is placed inside the laser. As we know that Helium and Neon are noble gases so they do not interact with getter in this way we get a pure mixture of Helium and Neon gas.

ARGON AND KRYPTON ION LASERS: Lasers emitted by Agron Krypton have wavelengths of the range of 514.5nm, 351nm, 465.8nm, 472.7nm and 528.7nm. It can also create white laser. An argon laser photo coagulator was developed for use

in Wilmer Eye Institute. It was used on a great success rate on about 400 patients. The main diseases which were treated from this type of technique were diabetic retinopathy, macular diseases, and assorted vascular conditions. The implementation of laser on eye was made direct or indirect by a device named ophthalmoscope. This technology was later improved for focusing on retina also. The ability of Argon laser to prevent retinal vessels was tested on rabbits. The implementation of the laser on retinal vessels was very successful. It occluded both the arteries and veins.

CO_2 LASERS: CO_2 laser is one of the earliest gas lasers. Now a days CO_2 is grouped in most highest power continuous wave lasers. The first ever gas laser which was developed by Kumar Patel in Bell Lab was CO_2 laser. It is also most famous laser of current age also.CO_2 laser is the among the highest power continuous lasers which are available now. These type of gas lasers are relatively efficient and there efficiency range is about 20 %. Infrared light having principle wavelength is produced by CO_2 laser centering about 9.4-10.6 micrometers. Special materials are needed for the construction of this type of lasers because this type of lasers operate in only infrared region. Normally mirrors coated with silver are used and the windows and other lenses are made of Ge or Si. The wavelengths of the laser emitted from carbon are 10.6μmand 9.4μm. These are the most efficient gas lasers there efficiency is about 30%. They are emitted by the low power electrical discharge. Tese are widely being used in industry for cutting processes, for the welding of steel and also in medical field for surgery. As we are concerned with the application of co2 laser in cardiology so we will discuss the working of only CO_2 laser.

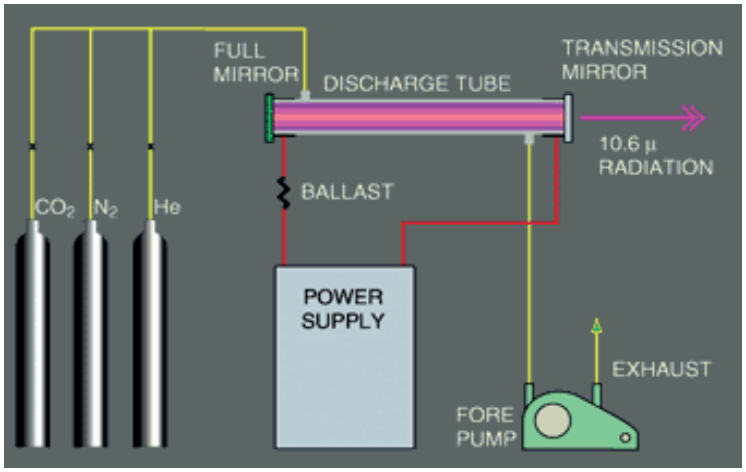


Figure: Working of Carbon Dioxide Laser

Source: https://laserscn.wordpress.com/tag/co2-laser/

However to get maximum output mirrors coated with gold, lenses and windows made with zinc solenoid are used. Diamond windows and lenses are also being used in some developed labs but they are very expensive. However they are most suitable for high-power applications because of their high thermal conductivity. In the past

lenses and windows were made of salt. Although it was a cheap material but with the passage of time and exposure to the atmosphere there quality was damaged and they degraded gradually. The gas lasers consist of 2 parts one is gas discharge and the other is output coupler. As we know gas lasers are the high power lasers that's why they are widely used in industry for laser cutting. These type of lasers also have applications in medical field because gas lasers are absorbent in water. Lasers are used in medical for skin resurfacing etc. however they gas lasers can also be used for some type of skin treatments like hirsute and papillary.

Applications of CO_2 laser: Lasers are very crucial in industry because of their wide application like cutting, drilling, scribing, welding, brazing, and soldering. CO_2 laser is the most famous in these applications. The major fields where the lasers are used are laser-welding and -adjusting of a miniaturized relies, Cutting of graphite cylinders to form a grating for high power transmitter tubes, and Cardiology. Comparing the number of papers which describe potential applications for excimer lasers with the number of processes introduced already in fabrication lines shows a striking incongruity: There are almost no published large-scale industrial applications for excimer lasers. The reason for this, at least from our point of view, is that the way down from proof of feasibility in the research laboratories to the production lines is sometimes very hard and may take several years.

CO_2 are broadly being used in many fields also on industrial level. This is just because it can create very powerful laser beams. There industrial applications include, drilling, cutting, scribing, machining, heat treatment, cladding and alloying. CO_2 have a long range of applications in medical field such as laser surgery, wound healing, neurosurgery, dermatology and revascularization. As we are concerned with the uses of CO_2 laser in revascularization which is also called TMR/TMLR so we will discuss revascularization only.

CO_2 Laser in Revascularization: In medical field many kinds of lasers are being used for different purposes based on their properties. But in case of cardiovascular surgery only few lasers have been tested successful so far. Since it is very critical that's why lasers have been applied in cardiology only in three fields which are 1) Trans-myocardial laser revascularization (TMLR), 2) Laser vascular anastomosis, and 3) Laser angioplasty in the peripheral arterial diseases. However in Japan lasers are being used in coronary artery bypass grafting also. With the passage of time different more efficient methods are being developed for revascularization by CO_2 laser. A laser with output power 100 watt and whose irradiation time was 0.2 seconds was used for the treatment of severely ill people as an experiment.

In this study, a feasibility of trans-myocardial laser revascularization from left ventricular cavity through artificially created channels by laser was precisely evaluated. When this technique was tested on dogs the results were very satisfactory that the 0.2mm holes created by laser in the dog's heart's left ventricle were patent even 3 years after their creation. Similarly when, trans-myocardial laser revascularization was

applied in a 55-year-old male patient with severe angina pectoris who had undergone pericardiectomy 7 years before. He was completely recovered from severe chest pain.

As our whole body need oxygen for survival similar is in the case of our heart. Our heart also needs a continuous supply of oxygen. That is supplied by blood carrying oxygen. This kind is delivered to heart by coronary arteries. However sometime the coronary arteries are damaged/jammed due to which the supply of oxygen carrying blood to the heart is affected. These arteries due to some kind of disease cannot supply blood to heart. Thus lack of oxygen carrying blood supply to heart results in a heart disease which is termed as ischemia. This shortage of oxygen carrying blood to heart muscle increases the risks of heart attack which is very painful and dangerous for human health. This condition is termed as angina.

Now the question is how to deal with such kind of disease? How to treat the patients facing angina? Sometimes coronary artery bypass is done. But this surgery is most of the times very dangerous for the patients facing serious health problems. Also most of the patients undergo bypass operations and cannot bear more surgeries. Such kind of patients are treated by a technique which is termed an TMR or TMLR. Coronary artery disease cannot be treated by TMLR but it can be done to reduce the pain caused by angina.

What is Trans-myocardial Laser Revascularization (TMLR)? Trans-myocardial Laser Revascularization is a technique which is used to reduce the pain caused by angina. Small holes which are called channels are drilled in heart muscle and left ventricle. This left ventricle is known as main pumping station of heart. The blood flows from these channels which carries oxygen.

After TMLR, when oxygen-rich blood enters the left ventricle, some of that blood can flow through the tiny channels and carry much-needed oxygen to the starving heart muscle. This method was first tested on alligators and snakes. The blood travels straight in the heart muscles and ventricles of snake. In this way doctors thought that this method can also work on humans. TMLR is a technique which may be called surgery but is done when heart is beating and is full of blood. Hence heart lung machine is not needed. This proves that TMLR is not an open heart surgery.

IMPORTANT THINGS: The surgeon should decide the operating time which is most suitable for the patient. The surgeon should have a brief history of the patient and his current situation. Before TMLR the ECG, blood tests, urine tests and chest x-rays are very necessary so that any injection can affect the recovery time. Before the operation the anesthesia is most important thing. Before anesthesia, make sure that the stomach of the patient should be empty. This is the safest way for anesthesia.

OPERATION DAY: The patients of angina are admitted in the hospital one day before the operation or sometimes in the morning of the operation date. Small metal disks which are called electrodes are attached to the chest of the patient which monitor the heart activates like heart's rhythm and electrical activity. These electrodes

are also connected to the electrocardiogram which allows them to monitor heart. Anesthesia is done before taking the patient in the operation theater. After the patient undergo asleep a tube connected to the machine which is called respirator is inserter on the patient's windpipe to take care of breathings. Another tube is inserted from patient's throat or nose down to the stomach which prevents the stomach to collect air or liquid. So that the patient may not feel sleepy or sick after waking up. Another tube is inserted into the bladder for the collection of any urine produced during the operation. The cardiovascular surgeon leads other surgeons and other operating staff and nurses.

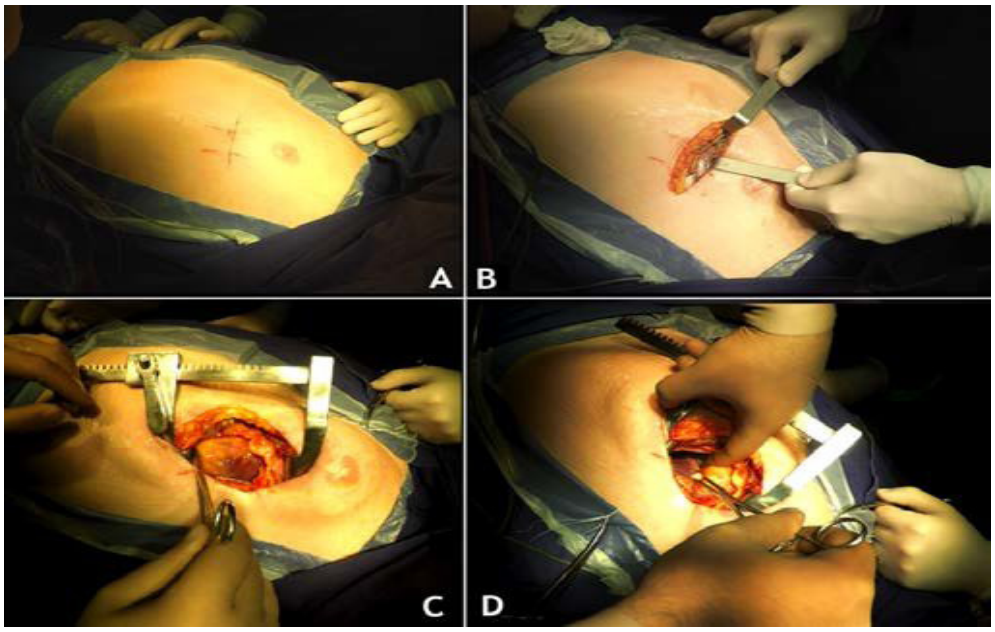


Figure: Stages of isolated TMLR procedure combined with intramyocardial injection of ABMSC (part 1): A) the surgical field with marking for a surgical approach; B) the pleural cavity exposed after incision of soft tissues using intercostal approach; C) exposure of the left ventricular apex and anterior wall after pericaridotomy; D) exposure of the left ventricular posterior wall after pericaridotomy.

Source: https://www.researchgate.net/figure/Stages-of-isolated-TMLR-procedure-combined-with-intramyocardial-injection-of-ABMSC-part_fig2_317012531

First of all a cut is made in the left side of patient's chest to reach heart's left ventricle. Then 20 -30 channels are made in the heart's muscles using carbon dioxide laser. The size of these channels is similar to a pin or about 1 mm wide. These channels are made only during hear beats. Because during heart beating the heart's walls become thick causing least damage. There may be chances of bleeding of walls which can be stopped by the surgeon by pressing lightly on the channels by fingers. These blood clots can block the top of the channels but these channels stay open inside the heart. All this process takes about 2 hours. In some cases one part of the heart is treated with heart bypass and the other part is treated by TMR and in some cases both cases are treated with TMLR.

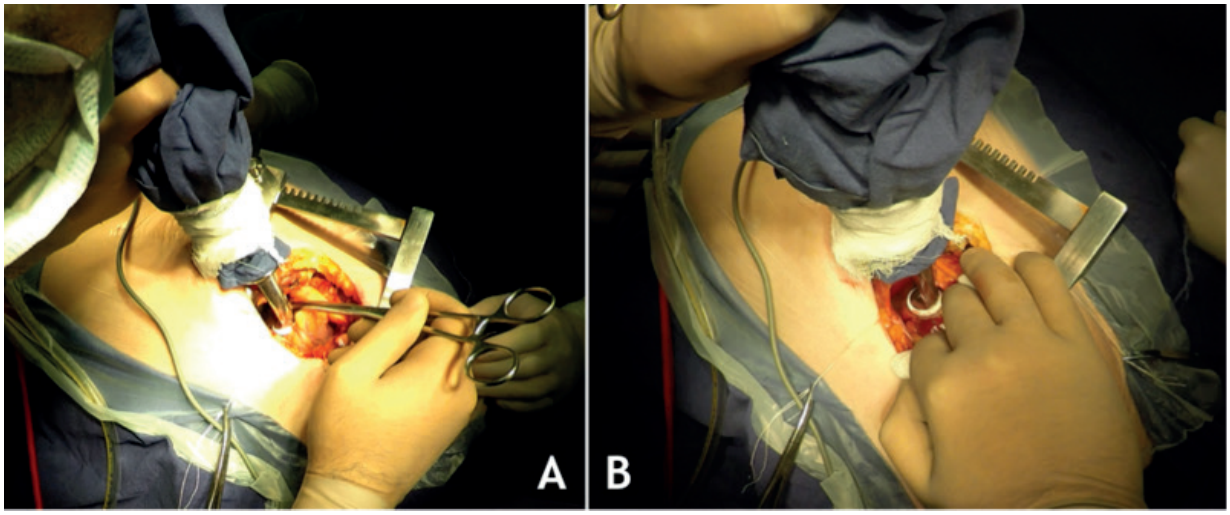


Figure: A) exposure and laser treatment of the left ventricular posterior wall; B) exposure and laser treatment of the left ventricular anterior wall.

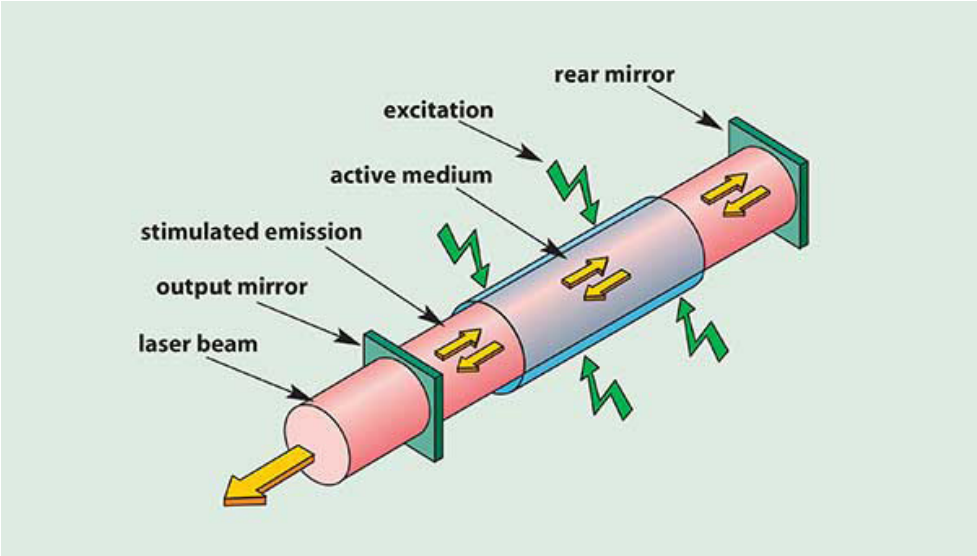
Source:https://www.researchgate.net/figure/Stages-of-isolated-TMLR-procedure-combined-with-intramyocardial-injection-of-ABMSC-part_fig3_317012531

RECOVERY TIME: It can be 4-7 days after TMLR. However it takes a long time to recover the patient is suggested to limit his activities. The patient may also suggested to join cardic rehabilitation or to start an exercise program. If the patient is on an office job he can continue after 6 weeks.

LIFE AFTER TMLR: The signs of coronary artery disease are decreased to a great extant after TMLR however to see clear improvements 3 months time is needed. About 80%-90% patients feel better then they feel before the TMLR. Also the risks of heart attacks are reduced in them**.**

ADVANTAGES OF GAS LASERS IN SURGERY: Lasers are used in every kind of surgeries in which removal of tissue or a cut on a tissue is needed. In general, the results of surgery using lasers are better than the results using a surgical knife. From pub-med data I have noticed that TMR with CO_2 gives a laser-resort option to the patient suffering from angina. It is also suitable for the patients of other diseases like diabetes which increase the chances of bypass. Although the clinical data in this field is very rare because it is a new technology but about 90% patients have seen noticeable improvements. A *New England Journal of Medicine* study concluded that patients who had TMR had relief of chest pain as well as improved quality of life, improved blood flow to the heart, and decreased hospital admissions. The procedure is relatively quick and is also covered by most insurance companies. i)Laser surgery takes less time than other conventional surgery methods ii) Lasers operate in a very small area so that very small area of the body is affected iii)As lasers are controlled by computer, gives a full view of interior and are perfectly applied on required position iv) Several operations can be done without opening body. It can be done by simply inserting fibers for transmitting lasers.

Basic Working of CO_2 laser: CO_2 is a gas laser in which a mixture of gas so called gain media is used for the generation of laser. This gain media consist of Carbon dioxide, Helium, Nitrogen, Hydrogen and water vapors. This type of laser is pumped up by a method known as gas discharge which is done by DC current, AC current or Radio frequency *(Paschotta, 2008)*. Wavelength of CO_2 laser is 10.6 μm. The efficiency of this laser ranges from 10-15 %. The heat required for the generation of CO_2 laser is achieved by the help of heat exchangers and turbines and blowers are also used for gas pumping. There are two parameters for characterization of gas lasers which are axial flow and other is cross flow.



(fig 3.1)

CO_2 laser is a kind of laser that is operated in infrared region that is why we need special methods and materials for the generation of this type of laser. Mostly Silver mirrors and germanium lenses are used. In order to get maximum efficiency golden mirrors and lenses made of zinc selenide are used. However now a days diamond windows and lenses are also being used but they are very expensive. The advantage of diamond lenses over other conventional lenses is that they have high thermal conductivity and can be used in high-power applications. In old age salt was used for the construction of lenses. The advantage was that the raw material was inexpensive but the disadvantage was that after the passage of the time and exposure to the atmosphere there quality was damaged. A simple CO_2 laser contains a total reflector at one end and an output coupler at other end. CO_2 laser can be constructed between power ranges from milli watts to kilowatts.

CO_2 is a very famous and widely used laser. It replaces flowing gas lasers just because of its wide application ranges. It also has an advantage over flowing gas lasers that it comes with a simple design.CO_2 gas lasers are further classified on the base of energy input. Gas is coupled with electrical energy directly in DC Lasers. All this is done with a metal placed between them from which gas discharge occurs. In

the other type the discharge occurs in the direction of flow of gas. These lasers are called axial flow lasers. Similarly when discharge occurs perpendicular to the gas flow this is called cross flow laser. However DC lasers can be produced easily and have high efficiency and have a large number of applications.

Carbon dioxide lasers are useful in surgical procedures because water absorbs this frequency of light much better. Laser surgery and skin resurfacing are examples of medical uses. CO_2 are used to treat particular skin conditions such as hirsute papillaris genitals by removing bumps. CO_2 lasers are also used to remove vocal fold lesions such as vocal fold cysts. Researchers in Israel are experimenting with using CO_2 lasers to attach human tissues as an alternative to traditional sutures. The 10.6µm CO_2 laser is the better surgical laser for the delicate tissues where both cutting and hemostasis are obtained photo thermally and CO_2 lasers also can be used instead of a scalpel for most processes and are even used in places a scalpel would not be used, in soft areas where mechanical trauma damage the surgical site. CO_2 lasers are suitable for delicate tissues process in human and animal specialties as compared to other laser wavelengths. Advantages include less bleeding, less surgery time, less risk of infection and less post of swelling. Uses include gynecology, dentistry oral, maxillofacial surgery, and many others. The CO_2 laser at the 9.25 - 9.6 µm wavelength is used in dentistry for strict tissues ablation. The hard tissues are ablated at temperatures as high as 5,000° C, producing clustering thermal radiation.

LASER ANGI: It is a method of opening coronary arteries which are blocked by plaque in it. This is done by a technique known as balloon angioplasty. However, angioplasty in done only when there is enough gap through which a balloon can go inside the vessel for digging hole in plaque that has blocked the vessel. A small flexible tube so called catheter is used in this method to remove plaque.

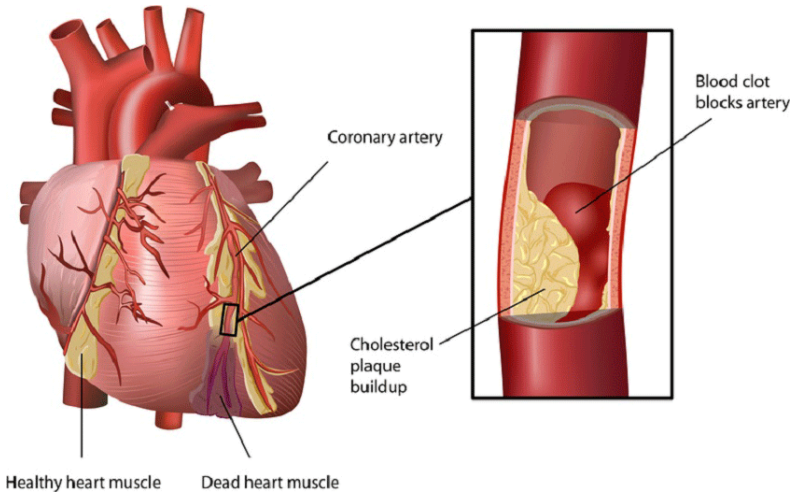


Figure: Remedies for Clogged Arteries https://www.pinterest.com/pin/701435710684145120/

CO_2 LASER IN REVASCULARIZATION: It is a technique in which small holes

are drilled in myocardial tissues It is done by using high power CO_2 lasers used for the treatment of the patients having end stage coronary disease. Thousands of patients suffering from end stage coronary disease have been treated with this method. The basic idea of trans-myocardial revascularization is based on the working of heart as the heart create perfusion through heart beats similarly through TMR small holes are drilled for the perfusion of myocardium.

LASER SYSTEMS FOR TMLR: CO_2 laser is the best Gas laser which is used for creating channels in the myocardium for the perfusion. However there are certain conditions for the creation of channels (holes) that it should be done in the time interval of 100 ms and a channel should be 20-40 mm long and its diameter should be 1 mm. and all this process should be done on a beating heart. All this process can be completed in one or multiple shots. But lot of thermal damage is dealt by the continuous laser. This can be minimized by using pulsed gas laser. However the laser should be very effective and its interaction with myocardial should be very strong.

Laser system	XeCl Excimer	Dye	Nd: YAG pulsed	Ho: YAG	CO_2 pulsed
Wavelength [nm]	308	400-800	1064	2100	10600
Pulse domain [μs]	0.01-0.15	1-10	~300	~300	10-2000
Max pulse energy [mJ]	300	1000	1000	4000	5000
Max rep rate [Hz]	200	10	10-40	10-40	1000
Max power [W]	10	10	100	80	100
Penetration depth [μm]	40	250	1400	300	20
Effect. Pen. Depth [mm]	1	3	3	6	30
Delivery device	Fiber	Fiber	Fiber	Fiber	Art. Arm
Absorbing component	Proteins water	Blood/Pigment	Pigments	Water	water

Table: Characteristics of laser systems for TMR are shown

EFFECTIVE PENETRATION DEPTH: Penetration depth is defined on the basis of tissue ablation by the laser when it is in microsecond region. Lasers have a very shallow penetration depth because it is highly absorbed by the tissue. For example the penetration depth of CO_2 lasers of the order of micrometers. Keeping these information in mind a surgeon can decide that these lasers are not suitable for creating deep holes. However laser pulse of first microsecond is enough for eliminating first layer of the tissue and creating a channel in it. The beam enters the hole continuing to vaporize the tissue at the bottom of the crater as long as the pulse lasts. This is the way which laser beam uses for penetrating into the tissue. A 300µs long pulse is used for creating a channel of 15 mm in the tissue. The volume of the tissue that can

be ablated is the factor that determines the effective penetration depth of laser. The size of channel depends on the diameter of fiber. Additionally, the expanding vapor can create fissures extending even deeper into the tissue.

Figure: Novadaq's CO2 laser system being used to create a channel in the myocardium to promote angiogenesis in infarct tissue

Source:https://www.dicardiology.com/article/transmyocardial-laser-revascularization-%E2%80%94-rethinking-therapy-complicated-patients

CO_2 LASER CHARACTERISTICS FOR TMLR: Optical fibers are not used for transporting lasers. However other media are used for transporting laser. These are transported by so called arms which are built of hollow tubes having reflecting surfaces same as mirrors positioned in groups. The reflectors can perform with high efficiency with proper materials. The transporting arm consists of 6 mirrors fixed on rotating holders which work as a steering for movement in any direction. A set of rigid tubes holds the rotators. If these rotators and mirrors are properly aligned then the laser beam emitted from the tube reaches the exact location and is independent on the movement of the tubes. That is why alignment of tubes is given much importance and this is very complicated. However in this method the properties of the laser remain unchanged after passing through the tubes. Only the diameter of the beam will change because it depends on the divergence of the beam and the length of the arm. The size of the beam is of the order of several millimeters. An optical system is used for focusing the beam on the targeted area. However the optical components that are used for different purposes should be compatible with the wavelength of beam. The choice of the lens is based on the requirements such as how far the target is. Lenses of fluorozirconate glass are used for carbon dioxide laser.

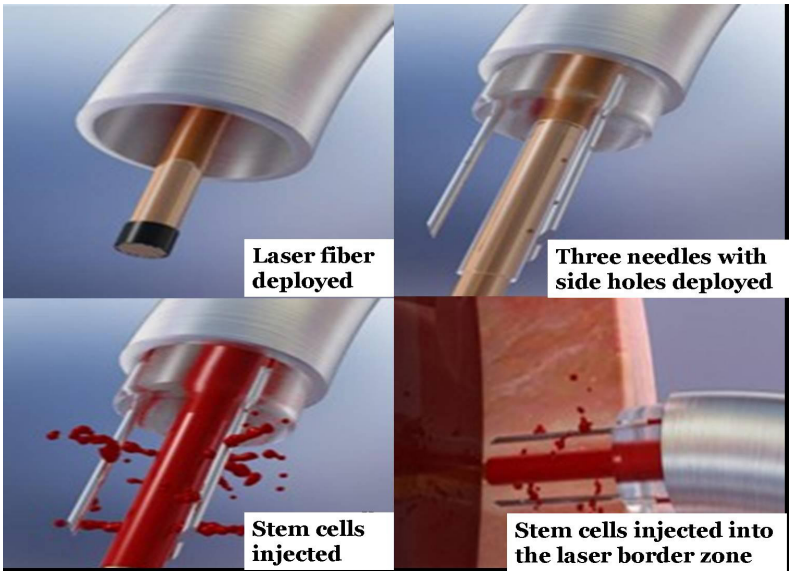
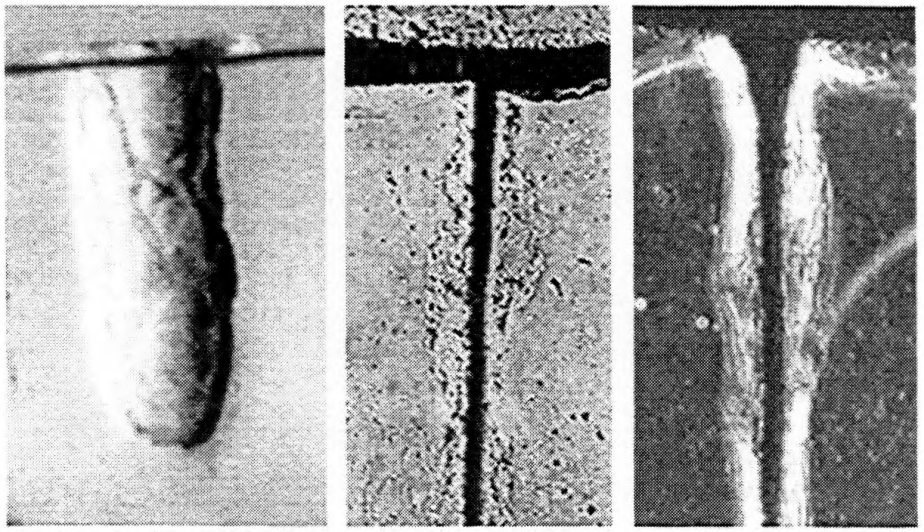


Figure: Transmyocardial laser revascularization

Source: http://ismics.org/abstracts/2008/MP5.cgi

FIBER DELIVERY FOR CO_2: Now day's optical fibers are also being used for the delivery of high power Carbon dioxide Laser pulses. The fibers having diameters of 500 to 1000 pm which consist of empty silica tubes with a special reflection coating on the inner wall. There are some problems are still need to be resolved before applying fibers in medical field.

PULSED CO2 LASER- TISSUE INTERACTION: During the laser pulse of several milliseconds a rapidly growing vapor channel is formed. These vapors create a free space of few millimeters in the tissue so that the beam could reach the lower layer of the tissue this process continues until left laser beam is reached in left ventricle chamber and the blood is vaporized. If the laser continues towards the left ventricle this is extended towards the blood. Ultimately this beam ca hit the other wall. Small tears can be produced along the wall of myocardium. Most of the ablation products escape through the surface of the epicedium. During the laser pulse, the wall of the Channel is heated by direct absorption of laser beam and by heat transfer from the superheated water vapor (figure 6,right). After the laser pulse, part of the condensation heat finds its way into the channel wall. The total thermal effect can be substantial, resulting in a zone of coagulation and necrosis along the channel wall.



(fig 3.6)

CO2 laser- tissue interaction. left: expanded channel during ablation, middle: collapsed channel with small cracks alongside, right: thermal effects along channel wall directly after the laser pulse.

Conclusion: It is noted from clinical data that TMLR improved the patients facing end stage coronary disease, refractory angina and ischemic heart disease. The success rate of trans-myocardial laser revascularization by CO_2 laser is 80% while 10% of patients fell no relief and death rate is 10%. In USA 200 patients of angina have been treated in 8 different hospitals since 1992. Average follow up for each patient was about 10 months and their average age was 63 years. The results observed were very good. Mortality rate was 9 %. Decrease in perfusion defects was noticed. All the medications and angina class were recorded. Hence they concluded that TMLR provided angina relief, decreased admissions in hospitals in this field and improved perfusion in patients suffering from severe artery disease.

Characteristics	TMR	MM
Aaberge (p<0.01)	44%	0%
Allen (p<0.001)	76%	32%
Burkhoff (p<0.001)	48%	14%
Frazier (p<0.01)	72%	13%
Schofield (p<0.001)	25%	4%

Table 2: Comparison of TMLR by CO_2 and YAG laser with medical treatment

In fig A there is a comparison of TMR by CO_2 laser with medical treatment and other conventional method. The relief in angina classes from both TMLR and MM is explained in the graph. By observing this graph we can conclude that TMLR is a better technique then MM. The main purpose of this technique is to study the effects of trans-myocardial laser revascularization with CO_2 laser on the patients facing the

problems of Angina and shortage of oxygen carrying blood in left ventricles of heart. TMR by CO_2 laser is a new technique which is currently being used in cardiology for the treatment of blood blockage in heart vessels. In MT this technique was applied on 100 patients having end stage coronary stage, were not eligible for being treated with conventional revascularization in 2000. They were kept under observation 3-12 months after TMLR. The results were very good a significant relief in angina symptoms was recorded. Increase in time to chest pain during exercise was recorded.

In 2014 TMLR was applied on over 1200 patients in National Institutes of Health, Bethesda, MD, USA. All the patients were suffering from end stage coronary disease. It was divided into 5 parts. CO_2 laser was used in 3 groups and in other 2 groups YAG gas lasers were used. Patients were divided into 3 groups on the base of fellow up of 3 months,6 months and 12 months. Noticeable improvements were noticed in both techniques.

In 2001 TMLR was applied on 78 patients suffering from angina. Their mean age was 61 years. The significant relief in angina class was noticed after an average fellow up of 5 years. There was no angina in 17% of patients. About 68 % of the patients felt a remarkable long term angina relief. TMLR proved a sole therapy for these patients because of its long term angina relief of more than 5 years. Trans-myocardial laser revascularization is an alternative to open heart surgery which provided a relief to the patients suffering from angina pain. It is proved as a sole therapy for these patients. FDA approved both CO_2 and YAG laser devices due to their effectiveness. TMLR is correlated with CABG for targeting ischemic areas on which bypass in not possible. Combination of TMR with adjuvant stem cell is also under consideration for better results and improvements in patients. TMLR is a latest technique which uses high power laser energy for creating holes which are termed as channels in the heart vessels to for continuous supply of Oxygen carrying blood to the heart.

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Agência Brasileira do ISBN
ISBN 978-85-7247-673-7