Jambura Medical and Health Science Journal, Vol.1 No.2 (August 2022)
p-ISSN 2830-0580 | e-ISSN 2830-4608

REVIEW ARTICLE **Open Access**

Retinal Laser Photocoagulation

Suleman N[1,2]*
[1]Department of Ophthalmology, Faculty of Medicine, Universitas Negeri Gorontalo, Gorontalo, Indonesia
[1]Department of Ophthalmology, Prof. Dr. H. Aloei Saboe General Hospital, Gorontalo, Indonesia

*Corresponding author. Email : naningsuleman@ung.ac.id, Telp : +62 813-4187-2027

ABSTRACT

Background: Panretinal photocoagulation (PRP) is the standard gold therapy to prevent vision loss in severe non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR).
Contents: Photocoagulation is a therapeutic technique using a solid light source to coagulate tissue. This light energy is absorbed by the retinal tissue and converted into thermal energy. This energy then causes the abnormal blood vessels in the retina to shrink and disappear. It takes approximately 6-8 weeks for complete shrinkage of blood vessels.
Conclusion: Laser retinal photocoagulation is the standard therapy in diabetic retinopathy patients. By causing thermal lesions of the pathological retinal vessels, the expected outcome can be achieved in 2-3 months of therapy.

Keywords: Diabetic Retinopathy, Laser, Panretinal Photocoagulation

JMHSJ
Jambura Medical and Health Science Journal

Article History:
Received 07August 2022
Accepted 31 August 2022
Published 31 August 2022

Published by:
Universitas Negeri Gorontalo

Address:
Jl. Jend. Sudirman No.6, Gorontalo City, Gorontalo, Indonesia

Mobile number:
+62852 3321 5280

Email:
jmhsj@ung.ac.id

Introduction

Panretinal photocoagulation (PRP) is the standard gold therapy for preventing vision loss in severe non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR). Laser photocoagulation provides a neovascularization regression effect to prevent and stop the progression of diabetic retinopathy. The laser beam used can cause minor burns on the peripheral retina. This burn causes abnormal blood vessels to shrink and disappear. It takes approximately 6-8 weeks for complete shrinkage of blood vessels.[1,2,3]

Laser Mechanism of Action

Light Amplification by Stimulated Emission of Radiation (LASER) is different from ordinary light in that it radiates in all directions according to the path of the light. Ordinary light also consists of a collection of light waves, each of which has a different wavelength, whereas laser light travels as parallel rays and almost does not spread. Laser light is a type of beam that is monochromatic and coherent.[4]

The process of producing laser light is called stimulated emission, where this process reproduces light waves. A material will usually release light through spontaneous emission. One of the electrons in the atom will absorb energy. Meanwhile, the atom stores energy in an excited state, and if the electrons release excessive energy, then spontaneous emission will occur. If a wave is released by an excited atom and hits another atom, then this second atom will be stimulated to release energy so that a second wave is formed which runs parallel and the same as the first wave, and if these two waves stimulate the other atom it will form an abundant of a coherent beam of light. The atoms will release photons that are visible as laser light.[4,5]

Laser Beam Effect

Direct and coherent laser beam radiation causes the beam to focus on a single point. The monochromatic laser beam can have different wavelengths to produce the desired beam effect on specific tissue layers. Laser effects in surgery include thermal, ionizing, and photochemical effects.[5,6]

Thermal effects can be in the form of photocoagulation and photo vaporization effects. The photocoagulation effect will occur in conditions where an increase in temperature of about 10ºC to 20ºC will cause the targeted eye tissue coagulation. This photocoagulation effect is often used in retinal laser surgery. The amount and speed of temperature depend on the target tissue's location and the absorption rate of the wavelength used. The photo vaporization effect will occur when laser energy increases the temperature of the cellular and extracellular fluids to reach 100ºC, resulting in heating and tissue

vaporization. Usually, the light used has a wavelength of weak penetration, so most of the laser energy is absorbed superficially and causes tissue tearing due to tissue vaporization. The ionization effect will occur if the beam with very high radiation and short exposure time in a small spot will produce electrons that get energy from the target tissue molecules and, in the end, form a free electron and ion plasma called plasma. The rapid expansion of the plasma causes sound waves and vibrations accompanied by stretching of the tissue, incision of the tissue, and then producing photodisruption of pigmented tissue or absorption of laser light. Transparent tissue can be torn in this situation, for example, in the NdYAG Laser (neodymium-doped Yttrium Aluminum Garnet Laser). Photochemical effects can occur through intense laser energy, which will occur when the photon energy is high enough. The energy of the photon will increase when the wavelength is short. The photochemical effect has been used in experiments using red light (630nm) to generate cytotoxic free radicals in tumors. [6]

Principal of Laser Retinal Photocoagulation

Photocoagulation is a therapeutic technique using a solid light source to coagulate tissue. The light energy is absorbed by the target tissue and converted into thermal energy. When the tissue temperature exceeds 65ºC, tissue protein denaturation and coagulative necrosis will occur. Most surgeons currently perform laser tissue photocoagulation using a light spectrum between 400-780 nm. Green, red, yellow, and infrared rays are commonly used for the posterior segment. This irradiation system can be transpupillary using a slit-lamp, indirect ophthalmoscope, endophotocoagulation during vitrectomy surgery, and transscleral using direct contact probing. [4]

The effectiveness of light in causing photocoagulation depends on the ability of the light to penetrate the ocular medium and how well pigments absorb the light in the target tissue, such as melanin, xanthophyll, and hemoglobin pigments. Melanin is the most important pigment in the eye and is present in the RPE cells and the choroid. Melanin absorbs light in the retinal pigment epithelium (RPE), the primary energy source in retinal photocoagulation. Melanin is very good at absorbing green, yellow, red, and infrared light. Xanthophylls are yellow pigments found in the retinal layer of the macula. Xanthophylls become a heat source when a photocoagulation laser with blue argon light is fired close to the fovea. Xanthophylls are very good at absorbing blue light, while yellow and red light is absorbed minimally. Hemoglobin is very good at absorbing argon rays and is a source of heat energy when most of the laser energy is concentrated in the blood vessels. Hemoglobin quickly absorbs blue, green, and yellow light but a small amount of red light. [4,5]

The choice of light wavelength depends on the therapy's goal. Based on the ability to absorb light from the tissue pigments, the surgeon will choose to achieve photocoagulation in the target tissue without damaging adjacent normal tissue. In addition, factors that must be considered are the area, including the depth and diameter, for effective coagulation to occur, which is directly related to the intensity and duration of radiation. Laser parameters such as spot size, duration, and power also depend on the refractory medium's clarity and the fundal pigmentation level.[4]

The selection of the optimum wavelength depends on the absorption spectrum of the target tissue. Generally, lasers that are often used for retinal photocoagulation are Argon rays, Krypton Yellow, and Diodes. Argon emits blue-green light at about 488-515nm. This light consists of 70% blue and 30% green. Argon can be converted to emit only green light by using a filter. As for Krypton Yellow light, emitting a beam of about 577nm, it is often used because of its ability to coagulate red lesions directly. In comparison, the Diode beam emits infrared at 780-950nm. [5]

Laser Parameters, Systems and Instruments

The three main parameters of the laser beam that need to be considered are spot size, power settings, and exposure time. Spot size varies between 50-500µm. It is essential to know that the smaller the spot, the greater the energy. Therefore, the power level must be reduced when changing the spot size to a smaller one. For focal therapy, the spot size is usually 50-100µm, while for pan-retinal photocoagulation, the spot is between 200-500µm. In addition, the power settings are energy power ranging from 0 to 3 W (0-3000mW). A highly pigmented fundus requires less energy when compared to a less pigmented fundus to produce the same combustion. Finally, the exposure time usually varies from 0.01 to 5 seconds. However, in some cases, intraocular tumor therapy requires a longer exposure time.[5,6]

Laser therapy can be delivered in three ways, namely slit lamp biomicroscope, laser indirect ophthalmoscope (LIO), and endolaser probe. Slit-lamp remains the method of choice in most cases, particularly in cases requiring precise laser application, such as photocoagulation of the macula. Contact lenses are used when using the slit lamp method, which functions as image magnification accompanied by the initial action of administering local anesthesia. LIO has been widely used since 1981, mainly for photocoagulation of peripheral retinal areas and for patients who previously could not be treated using the slit lamp method, such as children and mentally retarded patients. LIO can be used for therapy with argon, krypton, and diodes. Together with diodes, LIO is quite adequate, and now LIO

has replaced cryotherapy in cases of Retinopathy of Prematurity. Laser therapy can also use an endolaser probe during vitrectomy surgery. The probing used combines laser function and illumination capability even with aspiration capability.[5-8]

Indications and Complications of Laser Retinal Photocoagulation

Panretinal scatter used to destroy ischemic tissue to eliminate neovascularization in the retina, iris, and optic disc and to eliminate vascular proliferation in diabetic retinopathy and retinal vein occlusion. Focal ablation for nonelevated neovascularization in PDR and choroidal disease is also indicated in pan-retinal scatter. It is also indicated in masking intraretinal vascular abnormalities such as microaneurysms, telangiectasias, and perivascular leaks. In addition, chorioretinal attachment is where there is limited ablation and treatment for focal therapy in pigment epithelial disorders such as leakage associated with CSCR (Central Serous Chorio Retinopathy). In general, laser retinal photocoagulation is indicated for treating severe NPDR, PDR, diabetic macular edema, central retinal vein occlusion, branch retinal vein occlusion, retinal tears, lattice degeneration, subhyaloid bleeding, and central serous chorioretinopathy.[7,9]

Complications that can occur due to laser photocoagulation include foveal damage such as foveal burn, macular edema, epiretinal membrane/macular pucker, foveal spillover, and scarring. Other complications include choroidal hemorrhage, fibrous tissue contraction, visual function effects, and rare complications such as iris burns, choroidal effusion, and vitreous hemorrhage. To minimize complications, anticipation can usually be done by changing the laser parameters, namely power, duration, and spot size.[7,10]

Conclusion

Laser retinal photocoagulation is the standard therapy in diabetic retinopathy patients. However, this therapy can also be used for other retinal disorders. This laser beam works by causing thermal lesions in the pathological tissue, thus providing the desired outcome.

Conflict of Interest

Nothing to declare

Funding Sources

Article writing using personal expense by the author

Acknowledgment

Nothing to declare

References

1. Neubauer AS, Ulbig MW. Laser treatment in diabetic retinopathy. Department of Ophthalmology, Ludwig Maximilians University, Munich, Germany. Ophthalmologica 2007;221(2):95-102
2. El-Bradey MH. Panretinal Photocoagulation (PRP) for Proliferative Diabetic Retinopathy (Pearls and Pitfalls). Assistant Proferssor of Ophthalmology, Tanta University.
3. Jalali S. Principles of laser treatment and how to get good outcomes in a patient with Diabetic Retinopathy. Lv Prasad Eye Institute Hyderabad.2004;6(1):4-8
4. Liesegang TJ, Deutsch TA, Grand MG, Laser Therapy for posterior Segment Diseases. Retina and Vitreus. Section 12. San Fransisco: American Academy of Ophthalmology,2003-2004:283-290
5. Kanski JJ, Milewski SA. Principle of laser photocoagulation. Disease of the macula a practical approach. China; Mosby, 2020:17-8
6. Sabates FN. Applied laser Optics : Techniques For retinal laser surgery. Duane's Clinical Ophthalmology, Lippincott Williams & Wilkins Publisher,2013.
7. Budhiastra P, Andayani A. LaserFotokoagulasi pada kelainan retina. Penatalaksanaan terkini penyakit mata. Divisi Vitreoretina FK Unud, RSUP Sanglah Denpasar ,2017.
8. Kenneth Fong. Retinal laser photocoagulation. Sunway Medical Centre. The medical journal of Malaysia, 2010: 65(1): 88-94
9. Christina Weng, Peter Karth. Panretinal Photocoagulation. American Academy of Ophthalmology. EyeWiki,2022
10. Jennifer Evans. Laser Photocoagulation for Proliferative Diabetic Retinopathy. Cochrane Library, Nov 2014 (11)