1064nm ND: YAG LASER EFFICIENCY ON NODULAR ANGIOMAS

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Summary

LASERs (light amplification by stimulated emission of radiation) are optical devices that generate a parallel, coherent beam of light, characterized by intensity, monochromaticity and directionality, with a narrow bandwidth and a large amount of energy. LASER devices can have different active media: liquid, solid, gaseous (diode, CO2, Argon, Alexandrite, Nd: YAG, etc.), each with a limited range of indications. The wave emitted by the Nd: YAG crystal, with a wavelength of 1064 nm, is focused on the skin and transmitted transcutaneously in a controlled way. It is then absorbed by oxyhemoglobin and transformed into thermal energy, which coagulates and subsequently destroys the target blood vessel, without affecting the overlying or perivascular tissue structures. Patients selected for LASER treatment had nodular angiomas. The parameters selected for the device emitting a wavelength of 1064 nm were: spot size of 3 or 5 mm, with a pulse duration of 10-30 ms and an energy of 160-180 J/cm^2. The 100% effectiveness of this method of treating vascular lesions consisted in the complete elimination of the treated blood vessels, without long-term sequelae in all cases.

Keywords: *nodular angioma, nevus flammeus, LASER, Nd:YAG, BBL.*

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Introduction

LASER-based devices are optical instruments that generate a coherent, parallel beam of light with a narrow spectrum of wavelengths (monochromatic beam), propagated over long distances without divergence or with an insignificant divergence, focusing on a very small area, with high energy and intensity. The term LASER stands for Light Amplification by Stimulated Emission of Radiation.

The applicability of LASER is varied, in various fields: medicine (scalpel, ablation, tattoo removal, vascular lesions, hyperpigmented spots, skin rejuvenation, dentistry, ophthalmology, acupuncture), microscopy, military applications, nuclear fusion, photochemistry, holography, spectrography, CD (compact disc) and DVD (digital versatile disc) recording and playback, fiber optic communications, geology, seismology and atmospheric physics, metrology, industry and commerce (metalworking and textiles, barcode readers, printing), industrial applications (welding, cutting, engraving, marking, notching, selective laser sintering, spark plasma sintering).

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From the point of view of the risk to the skin and retina of the operator/doctor, LASER transmitters fall into 4 categories, some with subclasses: class 1 (does not require goggles or mask, the device has a well-covered area of action, being safe in all conditions of normal use: telescope, microscope, CD/DVD reader), 1M (does not require goggles or mask, safe for all conditions of use, unless it is magnified, such as microscopes and telescopes), 2 (does not require goggles or mask, considered safe, bright light blink reflex limiting exposure to a maximum of 0.25 s: visible light laser 400-700 nm: some laser pointers, rangefinders, construction lasers, some medical lasers), 2M (does not require goggles or mask, safe due to blink reflex, unless passed through magnification optics), 3R (requires special training in occupational safety and wearing special goggles, considered safe if handled carefully, with restricted beam viewing: powerful laser measuring and control equipment, laser pointers for presentations, lasers for firearms, lasers with power ≤ 5 mW, which may accidentally cause retinal burns), 3B (requires special training in occupational safety and wearing special goggles, dangerous when viewing the beam directly, but normally safe when viewing diffuse reflections: some medical lasers, CD/DVD burners, lasers with power ≤ 500 mW, which may accidentally cause retinal burns), 4 (requires special training in occupational safety and wearing special goggles, masks and protective gloves, is dangerous to the eyes due to direct beam and mirror reflections and sometimes even due to diffuse reflections, can cause fires and damage the skin: most military, industrial, medical and scientific lasers, lasers with power ≤ 500 mW). Medical lasers can have divergent emissions and require knowledge of the nominal eye hazard distance and the nominal eye hazard area.

NAMMD (National Agency for Medicines and Medical Devices of Romania) publishes the list of approved LASER distributors and warns about attempts to introduce non-compliant medical devices in the distribution chain, which do not comply with applicable regulatory requirements, in accordance with Article 926 of Law 95/2006 on health care reform, republished, as subsequently amended and completed. Every

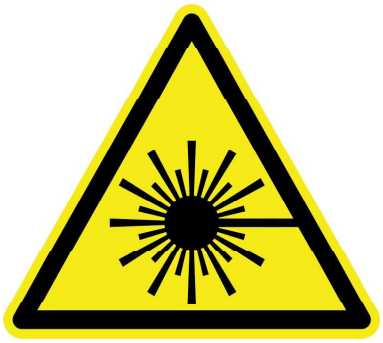

Figure 1: Class 2 and above warning label, obligatorily displayed on the cabinet door

doctor who intends to purchase a LASER device consults the NAMMD website in Romania, constantly updated with such information, and ensures that the products come from authorized distributors.

Medical LASER devices can have different active media: liquids (methanol, ethanol, ethylene glycol stained with rhodamine, fluorescein, coumarin), solids (ruby, neodymium, Nd:YAG, Er:YAG, Alexandrite, diode semiconductors), gaseous (Helium + Neon, CO2, Argon, Krypton, etc.), each with a limited range of indications.

Vascular lasers have evolved considerably from the initial continuous wave ones. In the 1960's, it was observed that the appearance of ruby and argon lasers, although it improved the color of port-wine stains (PWS, nevus flammeus) and hemangiomas, led to an increased rate of residual scar lesions and pigmentary changes, complications caused by non-specific warming of the skin. In 1983, Anderson and Parrish developed the concept of selective photothermolysis, through which laser energy could be used to destroy certain target components of the skin, minimizing collateral damage to the surrounding tissue [1].

Transcutaneous vascular lasers are: KTP Kalium-Titanyl-Phosphate (532 nm), PDL Pulsed Dye Laser (585 nm and 595 nm), Alexandrite (755 nm), Diode (800-900 nm), Nd:YAG (1064 nm), Diode + Indocyanine> PDL, Diode + Indocyanine> Diode [2-4]. Table 1 describes their characteristics, with emphasis on their parameters, but also on the advantages or disad-

Table 1 – Main lasers and light sources used in vascular surgery (8)

Laser type	Absorption and penetration	Common parameters	Major indications	Disadvantages
KTP (532 nm)	Oxyhemoglobin > Melanin; 1 mm	Duration (D): 2-100 ms; Energy (E): 3-45 J/cm^2; Spot size (SS): 1-6 mm; Cooling (C): with/without; Multiple transitions: possible	Facial telangiectasias, diffuse erythema, rosacea, cherry and spider angiomas, PWS, thin lower limb venectasias (<1 mm), poikiloderma of Civatte	Effective only for superficial vessels; dyschromia or changes in skin texture in people with dark skin; rare scars.
PDL (585-595 nm)	Oxyhemoglobin > Melanin; 1 mm;	D: 0.45-50 ms E: 5-24 J/cm^2; SS: 1-10 mm; C: yes Multiple transitions: possible	PWS, cherry and spider angiomas, infantile hemangiomas, facial telangiectasias, thin lower limb venectases, rosacea, poikiloderma of Civatte.	Same as KTP, especially for superficial vessels; pain, bruising.
Alexandrite (755 nm)	Melanin > Deoxyhemoglobin > Oxyhemoglobin; 2,5-3 mm	D: 3-80 ms; E:: ≤ 90 J/cm^2; SS: 1-10 mm; C: yes Multiple transitions: possible	PWS greater lower limb venectasis	Increased risk of hyperpigmentation and scarring especially in people with dark skin
Diode (800-900 nm)	Oxyhemoglobin ≥ Melanin; 3-5 mm	D: 10-150 ms; E: ≤ 500 J/cm^2; SS: ≤ 15 mm; C: with/without.	Facial telangiectasias, PWS, lower limb venectasis, venous lakes	Eligible for large diameter vessels; clinical data on their efficacy are scarce.
Nd:YAG (1064 nm)	Melanin absorption ratio: blood similar to PDL, but higher energies are required (low overall absorption); 5-6 mm	D: 3-300 ms; E: ≤ 600 J/cm^2; SS: ≤ 18 mm; C: yes; Multiple transitions: no	PWS, greater venectasis of the lower limbs, infantile angiomas, venous malformations, pyogenic granuloma	Pain, risk of burning and scarring
IPLS (500-1200 nm)	Filters for vascular damage: 550 and 570 nm	Various durations and delays of the pulse	F acial telangiectasia, diffuse erythema; rosacea, PWS, poikiloderma of Civatte, thin lower limb venectasis	Pain, burning, depigmentation; the parameters are difficult to set due to the multitude of devices

vantages of using each of the lasers, depending on the type of vascular lesion.

In the case of skin vascular lesions, oxyhemoglobin is the chromophore for the Nd:YAG laser (Neodymium-doped Yttrium Aluminum Garnet, Nd:$Y_3Al_5O_{12}$). Thus, the laser wave emitted and transmitted transcutaneously is absorbed by oxyhemoglobin, the thermal energy causing the coagulation and then the destruction of the target blood vessel, without affecting the overlying tissue structures. The therapeutic principle of the Nd:YAG laser is characterized by the creation of lesions in the vascular endothelium, which results in obstruction of the venous lumen [5].

The indications for Nd:YAG laser are varied, in addition to the treatment of vascular lesions, having applicability in: ophthalmology, plastic surgery, medical aesthetics (hair removal, tattoo removal, non-ablative skin remodeling, reduction of wrinkles, scars, treatment of pilonidal cyst), industrial production (engraving of metals and plastics, cutting, welding of steels and superalloys, fast, automatic fabrication, subsurface marking in transparent materials, such as glasses or organic lenses for glasses with the manufacturer's initials: Z, N, R etc.), Dynamics

fluids (particle image velocimetry or induced fluorescence), light shows (volumetric effects in artificial fog, or projection of graphics, cartoons and dynamic written text).

In order to be more easily tolerated by the patient, topical anesthetics may be applied 60 minutes before the start of Nd:YAG laser treatment [6]. There have been controversies regarding the application of local anesthetics, such as causing vasoconstriction of blood vessels, and this negatively affecting the results of treatment, but they have been clarified [7]. The cooling used during the procedure provides comfort to adult patients and reduces the need to use any topical anesthetic.

Post-procedure care is done with gentle topical emollients or lactoferrin cream (Kelapher or Chelaskin) and the use of irritants such as soaps, bubble baths or shampoos is avoided. Makeup is allowed only 3-4 days after treatment. It is mandatory to avoid exposure of the treated area to the sun, 2-4 weeks before the laser and 1-2 weeks after the laser, which is why we recommend topics with filters for infrared radiation, ultraviolet A, B, visible spectrum (360°). If blistering or crusting occurs after laser therapy, a topical antibiotic ointment may be prescribed.

Material and method

The LASER device chosen by us to treat vascular lesions in recent years is Nd:YAG with a wavelength of 1064 nm on the Cynosure Elite+ dermato-aesthetic station. Oxyhemoglobin is a chromophore for the Nd:YAG LASER, and the therapeutic principle of this type of laser is to create damage to the vascular endothelium, the ultimate goal being to block the venous lumen. The LASER wave emitted and transmitted transcutaneously is absorbed by oxyhemoglobin and transformed into thermal energy, which coagulates and then destroys the target blood vessel, without affecting the overlying or perivascular tissue structures. I chose this type of Nd:YAG LASER device after an experience of over 12 years with three more devices from different manufacturers. For nodular angiomas of patients eligible for LASER treatment, the wavelength of 1064 nm was used, with spots measuring 3, 5 or 7 mm in diameter, with a pulse duration ranging from 10 to 30 ms and an energy of 160 to 180 J/cm^2. The 100% effectiveness of this method of treating vascular lesions consisted in the disappearance of treated blood vessels, without sequelae in most cases. We present two cases of patients of different ages, background and sex, with angiomatous lesions with an evolution of 6 months and 50 years, respectively, located on the skin in the first case and on the lip semimucosa in the second case and for which the agreement for publication was signed by the patient or his parents.

Case 1. An urban male patient, aged 1 year and 4 months, Fitzpatrick II phototype, comes for a nodular lesion, red-colored, 5 mm in diameter, located at the level of the right genian skin region, asymptomatic, onset about 6 months ago.

It was decided to perform laser treatment, and the patient's parents signed the informed consent. The parameters used were: wavelength 1064 nm, spot size 3 mm diameter, pulse duration 30 ms, energy 160 J/cm^2, no overlapping pulses, with cooling stage 8 Cooler Cynosure, in 2 treatment sessions every 2 months interval, with application of Chelaskin 2-3 times/day, for 1-2 weeks after each session.

Case 2. A 72-year-old rural female patient, Fitzpatrick III phototype, comes for the evaluation of a prominent formation, located at the level of the left lower lip semimucosa, asymptomatic, which appeared about 50 years ago. On clinical examination, a compressible, bluish nodular lesion with a diameter of 4 mm is found.

It was decided to perform laser treatment, and the patient signed the informed consent. The parameters used were: wavelength 1064 nm, spot size 5 mm diameter, pulse duration 20 ms, energy 170 J/cm^2, no overlapping pulses, with cooling stage 7 Cooler Cynosure, 1 treatment session, with application of Kelapher 2-3 times/day, for 10 days after the laser session.

Results

The efficiency of the Nd:YAG laser treatment was very good, as shown in Photos 1-4. In patient 1 there is only a discrete hypopigmented hypotrophy, perceptible only in certain incidences of lateral light on the skin surface examined, temporarily, at the site of the former

Figure 2: Case 1: Nodular angioma - before treatment

Figure 3: Case 1: Nodular angioma - 1 year after treatment

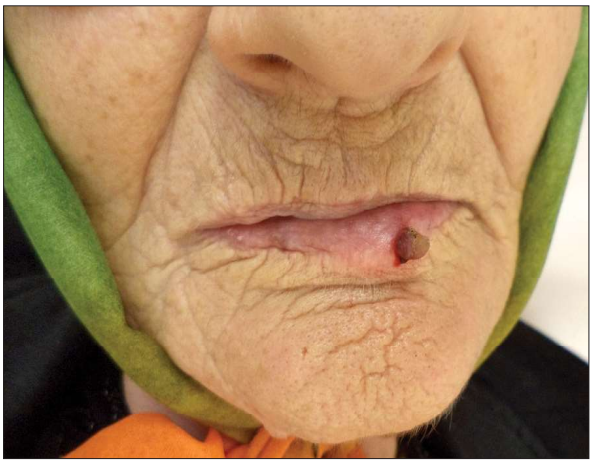

Figure 4: Nodular angioma - before treatment

Figure 5: Case 2: Nodular angioma - 2 months after treatment

lesion, which was no longer detectable on clinical or dermatoscopic examination after 2 years. In case 2 the lower lip has a normal appearance, without changes, 2 months after the intervention.

Discussions

Skin vascular lesions, especially those that are located on exposed areas - facial, atrial, cervical areas-, can cause psychological stress to the patient [9]. This is also the reason why treating them with the avoidance of complications has become a desideratum for both patients and doctors who choose the best performing devices.

The International Society for the Study of Vascular Anomalies (ISSVA) published in 2014 an updated classification of vascular anomalies, according to which lesions can be grouped into vascular tumors, characterized by a proliferation of blood vessels, and vascular malformations, described as blood vessels with abnormal structure [1].

Cutaneous nodular angiomas, a particular type of vascular tumor, are the most common

vascular pathology, along with port-wine stains (nevus flammeus), for which patients seek laser treatment [1]. For nodular angiomas we chose the 100% efficient Nd:YAG LASER therapy, and for port-wine stains we obtained very good results with the BBL (BroadBand Light) device.

The last three decades have seen major advances in the use of lasers to treat skin vascular lesions. Lasers are extremely variable and can differ in wavelength, pulse duration, flux, spot size and cooling methods. Most often, lasers are classified by wavelength, because it varies in their absorption by different tissues and the depth with which a laser can penetrate the skin. Lasers with shorter wavelengths, for example PDL, with a wavelength of 585 nm, are well absorbed by the blood and pigment, but are not able to penetrate deep into the skin. On the other hand, lasers with longer wavelengths, for example Nd:YAG, with a wavelength of 1064 nm, are poorly absorbed by blood and pigment, so they are able to penetrate deeper into tissues [4]. The main chromophore targeted during the treatment of vascular lesions is oxyhemoglobin in the blood, and these vessels are often located at or below the dermoepidermal junction. Therefore, darker skin, which has higher amounts of melanin that absorbs laser waves, often requires longer wavelengths to act on deep blood vessels [11].

Complications caused by laser treatments applied to vascular lesions, with appropriate parameters, are rarely reported in the literature. In China, a retrospective analysis of 100 patients reported a complication rate of 14%, with the most common complication being pigment changes. This, however, may reflect the variable incidence of skin-dependent post-laser complications. The most common complications reported after vascular laser are erythema, edema, pigment changes, blisters, and crusts. Less well known is the fact that laser complications include retinal lesions. Therefore, the use of eye protection equipment is imperative during laser treatment, both for the doctor (transparent glasses) and for the patient (metal, opaque glasses]. If procedures are performed on the eyelids, near the eyes, lubricated corneal shields should be applied to patients if they have not previously undergone corneal surgery. Cooling methods are essential to reduce the energy-related complications of, for example, crusts and blisters [11].

Conclusions

The Nd:YAG laser is the most effective means of treating nodular vascular lesions, a gold standard, with the possibility of obtaining the most aesthetic results and an extremely low complication rate, compared to other available methods, such as electrocautery, cryotherapy, application of cytotoxic substances, surgical excision.

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Conflict of interest
NONE DECLARED

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