Blood - Effects of Laser Therapy

Nan Fang Yi Ke Da Xue Xue Bao. 2008 Aug;28(8):1400-1.

[Low-energy semiconductor laser intranasal irradiation of the blood improves blood coagulation status in normal pregnancy at term.]

[Article in Chinese]

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OBJECTIVE: To explore the effect of low-energy semiconductor laser intranasal irradiation of the blood on blood coagulation status in healthy pregnant women at term. METHODS: Low-energy semiconductor laser was introduced into the nasal cavity in 126 healthy pregnant women at term and 123 healthy young unmarried women as the control group. The plasma prothrombin time (PT), activated partial thromboplastin time (APTT), thrombin time (TT), and fibrinogen levels were examined using transmissive turbidimetry after the therapy. RESULTS: PT, APTT and TT levels were significantly lowered, whereas fibrinogen level significantly increased in the healthy pregnant women before the laser therapy as compared with those in the control group ($P<0.01$). After intranasal laser therapy, these parameters were significantly improved in the healthy pregnant women ($P<0.05$) although there were differences from those of the control group. CONCLUSION: Low-energy semiconductor laser intranasal irradiation of the blood can effectively improve high blood coagulation status in healthy pregnant women at term.

J Physiol Pharmacol. 2007 Nov;58 Suppl 5(Pt 2):729-37

The influence of low-power helium-neon laser irradiation on function of selected peripheral blood cells.

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The effects of low-level laser light irradiation are debatable and the mechanisms of its action are still unclear. This study was conducted to test the effects of low-level laser irradiation on

human blood cells: erythrocytes, granulocytes, and lymphocytes. Whole blood obtained by phlebotomy was irradiated at 632.8 nm by using energy fluences 0.6 J/cm2. An analysis of blood gases revealed an increase in PO2 and SaO2 (P<0.001) in irradiated blood. No shifts in PCO2 and pH were recorded. Spontaneous synthesis of DNA in T and B blood lymphocytes decreased significantly after laser irradiation (P<0.02 and P<0.04, respectively). Phytohemagglutinin (PHA)-induced proliferation of T cells and SAC proliferation of B cells, expressed as a stimulation index, were statistically higher in the samples of irradiated than in non-irradiated blood (P<0.01). Chemiluminescence of fMLP-stimulated granulocytes from irradiated blood increased in comparison with non-irradiated samples (P<0.001). No changes of spontaneous and stimulated chemiluminescence kinetics in irradiated samples were observed. These results reveal the influence of photodynamic reactions on the ability of blood to transport oxygen and on immunomodulatory effects on leukocytes.

Physiol Res. 2006;55(2):189-94. Epub 2005 May 24

The response of Na+/K+ -ATPase of human erythrocytes to green laser light treatment.

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The objective of this study was to investigate the response of Na(+)/K(+)-ATPase of human erythrocytes to green laser irradiation. Effects of green laser light of fluences 9.5-63.3 J.cm(-2) and merocyanine 540-mediated laser light treatment were studied. Isolated erythrocyte membranes (protein concentration of 1 mg/ml) were irradiated by Nd:YAG laser (532 nm, 30 mW) and then incubated in a medium with 2 mM ATP for 30 min. Activity of ATPase was determined colorimetrically by measuring the colored reaction product of liberated inorganic phosphate and malachite green at 640 nm. Contribution of Na(+)/K(+)-ATPase to overall phosphate production was determined using ouabain. A positive effect of green laser light on Na(+)/K(+)-ATPase activity was observed. The dependence of enzymatically liberated inorganic phosphate on light fluence showed a linear correlation (R(2)=0.96, P=0.0005) for all fluences applied (9.5-63.3 J.cm(-2)). On the other hand, MC 540-mediated phototreatment caused a suppression of enzyme activity.

J Clin Laser Med Surg. 2004 Apr;22(2):111-7.

Effect of low-intensity (3.75-25 J/cm2) near-infrared (810 nm) laser radiation on red blood cell ATPase activities and membrane structure.

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OBJECTIVE: The biostimulation and therapeutic effects of low-power laser radiation of different wavelengths and light doses are well known, but the exact mechanism of action of the laser radiation with living cells is not yet understood. The aim of the present work was to investigate the effect of laser radiation (810 nm, radiant exposure 3.75-25 J/cm(2)) on the structure of protein and lipid components of red blood cell membranes and it functional properties. The role of membrane ATPases as possible targets of laser irradiation was analyzed. BACKGROUND DATA: A variety of studies both in vivo and in vitro showed significant influence of laser irradiation on cell functional state. At the same time another group of works found no detectable effects of light exposure. Some different explanations based on the light absorption by primary endogenous chromophores (mitochondrial enzymes, cytochromes, flavins, porphyrins) have been proposed to describe biological effects of laser light. It was suggested that optimization of the structural-functional organization of the erythrocyte membrane as a result of laser irradiation may be the basis for improving the cardiac function in patients under a course of laser therapy. MATERIALS AND METHODS: Human red blood cells or isolated cell membranes were irradiated with low-intensity laser light (810 nm) at different radiant exposures (3.75-25 J/cm(2)) and light powers (fluence rate; 10-400 mW) at 37 degrees C. As the parameters characterizing the structural and functional changes of cell membranes the activities of Na(+)-, K(+)-, and Mg(2+)-ATPases, tryptophan fluorescence of membrane proteins and fluorescence of pyrene incorporated into membrane lipid bilayer were used. RESULTS: It was found that near-infrared low-intensity laser radiation changes the ATPase activities of the membrane ion pumps in the dose- and fluence rate-dependent manner. At the same time no changes of such integral parameters as cell stability, membrane lipid peroxidation level, intracellular reduced glutathione or oxyhaemoglobin level were observed. At laser power of 10 mW, an increase of the ATPase activity was observed with maximal effect at 12-15 J/cm(2) of light dose (18-26% for the total ATPase activity). At laser power of 400 mW (fluence rate significantly increased), inhibition of ATPases activities mainly due to the inhibition of Na(+)-, K(+)-ATPase was observed with maximal effect at the same light dose of 12-15 J/cm(2) (18-23% for the total ATPase activity). Fractionation of the light dose significantly changed the membrane response to laser radiation. Changes in tryptophan fluorescent parameters of erythrocyte membrane proteins and the increase in lipid bilayer fluidity measured by pyrene monomer/excimer fluorescence ratio were observed. CONCLUSIONS: Near-infrared laser light radiation (810 nm) induced long-term conformational transitions of red blood cell membrane which were related to the changes in the structural states of both erythrocyte membrane proteins and lipid bilayer and which manifested themselves as changes in fluorescent parameters of erythrocyte membranes and lipid bilayer fluidity. This resulted in the modulation of membrane functional properties: changes in the activity of membrane ion pumps and, thus, changes in membrane ion flows.

J Clin Laser Med Surg. 2002 Apr;20(2):71-5.

Effect of red laser light on Na+,K(+)-ATPase activity in human erythrocyte membranes sensitized with Zn-phthalocyanine.

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OBJECTIVE: The influence of laser light (670 nm) on human erythrocyte membrane Na+,K(+)-ATPase activity in the presence and absence of Zn-phthalocyanine (ZnPc) was studied. BACKGROUND DATA: The response of erythrocyte membranes to low-power laser irradiation has not been fully elucidated. In our study, we focused on the studies on photo-induced changes of Na+,K(+)-ATPase activity. The erythrocyte membrane suspensions were incubated with 2 mM of ZnPc and next irradiated with energy doses of 19.1, 38.2, 57.3, 76.4, and 95.5 J x cm(-2). MATERIALS AND METHODS: The activity of Na+,K(+)-ATPase was assayed colorimetrically at the wavelength of 820 nm and expressed in micromol of inorganic phosphate released from ATP per mg of protein. RESULTS: The measurements of Na+,K(+)-ATPase activity in erythrocyte membranes incubated with ZnPc in the dark demonstrated that all concentrations of the dye (0.5, 1, 2, and 3 microM) stimulated enzyme activity. The concentration of 2 microM caused the smallest increase of enzyme activity, so this concentration was accepted for further studies. Irradiation of erythrocyte membranes in the presence of the dye (2 microM) significantly decreased Na+,K(+)-ATPase activity. Only for energy doses of 19.1 and 38.2 J x cm(-2) was the enzyme activity comparable to the activity of the control. CONCLUSION: It was found that irradiation with all energy doses applied caused a rise of enzyme activity. In the presence of ZnPc, significant decrease of Na+,K(+)-ATPase activity was observed.

J Clin Laser Med Surg. 2003 Dec;21(6):351-5.

Low-intensity near-infrared laser radiation-induced changes of acetylcholinesterase activity of human erythrocytes.

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OBJECTIVE: The aim of the present study was to investigate the transformations of red blood cells produced by low-intensity infrared laser radiation (810 nm). BACKGROUND DATA: Low-intensity (the output power of a laser device in the milliwatt range) laser radiation as a local phototherapeutic modality is characterized by its ability to induce non-thermic, nondestructive photobiological processes in cells and tissues. However, the exact theory concerning the therapeutic effects of laser biostimulation has not been

developed. MATERIALS AND METHODS: The suspensions of human erythrocytes in PBS (10% hematocrit) were irradiated with near-infrared (810 nm) therapy laser at different light doses (0-20 J) and light power (fluence rate; 200 or 400 mW) at 37 degrees C. As the parameters characterizing the cell structural and functional changes membrane acetylcholinesterase (AchEase) activity, the membrane potential, the level of intracellular glutathione, the level of products of membrane lipid peroxidation, and the cell osmotic stability were measured. RESULTS: It was found that near-infrared low-intensity laser radiation produced complex biphasic dose-dependent changes of the parameters of AchEase reaction in the dose-dependent manner: at smaller doses of radiation (6 J) the maximal reaction rate and Michaelis-Menten constant value decreased, and at higher radiation doses these parameters increased. No significant changes of erythrocyte stability, cellular redox state (reduced glutathione or lipid peroxidation product levels), or cell membrane electrochemical potential were observed. CONCLUSION: Low-intensity near-infrared laser radiation (810 mn) produced AchEase activity changes, reflecting the effect of light on the enzyme due to energy absorption. Protein molecule conformational transitions and enzyme activity modifications in cells have been suggested as laser radiation-induced events.

J Clin Laser Med Surg. 1993 Aug;11(4):185-9.

Effect of low-power He-Ne laser on deformability of stored human erythrocytes.

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This study was designed to investigate the effect of the He-Ne laser (continuous wave, lambda = 632.8 nm, 8.5 mW in power) irradiation on human erythrocyte deformability. Blood samples were obtained from hematologically normal adult donors by venipuncture. Red cells were washed and adjusted to 30% Ht with 0.9% NaCl solution (pH 7.00). Red cell solution samples were assigned to three groups. Each sample was divided into seven 3-ml working aliquots. The aliquots in Group I were irradiated for 0 (control), 1, 3, 5, 10, 15, and 30 min within 2 hr after sampling. The aliquots in Group 2 and Group 3 were stored at 5 degrees C for 24 and 36 hr, respectively, and received similar irradiations after 12 hr (in both groups), 24 hr (in Group 2), and 36 hr (in Group 3) from sampling. Red cell deformability was measured by the Nuclepore filter filtration and presented as the filter filtration rate (FFR). The deformability shown as FFR was unchanged in Group 1 (fresh cell group) from the control value, but improved significantly in Groups 2 and 3 (damaged cell groups) after the irradiation. These results suggested that the irradiation of low-powered He-Ne lasers improved cytoskeletal protein activities in damaged erythrocytes.

Artif Organs. 2000 Nov;24(11):870-3.

Low power laser protects human erythrocytes In an In vitro model of artificial heart-lung machines.

Itoh T, Murakami H, Orihashi K, Sueda T, Kusumoto Y, Kakehashi M, Matsuura Y.
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The protective effect of the low power helium-neon (He-Ne) laser against the damage of human erythrocytes in whole blood was examined in a perfusion model using an artificial heart-lung machine. Preserved human whole blood was diluted and perfused in 2 closed circuits with a double roller pump. The laser irradiated one of the circuits (laser group), and none the other (control group). In the laser group, erythrocyte deformability and erythrocyte adenosine triphosphate (ATP) levels were significantly higher, and free hemoglobin levels were significantly lower than those in the control group. Subsequent morphological findings by means of scanning electron microscope were consistent with these results. Low power He-Ne laser protected human erythrocytes in the preserved diluted whole blood from the damage caused by experimental artificial heart-lung machines. The clinical application of low power laser treatment for extracorporeal circulation is suggested.

Klin Khir. 2000 Nov;(11):28-9.

[The first experience of application of photo-modified erythrocytes for the treatment of the chronic arterial ischemia syndrome]

[Article in Russian]

Boiko VV, Grinevich VN, Lodianaia IN.

Efficacy of application of intraarterial erythrocytes infusion, photomodified by using low-energy laser irradiation, was proved, basing on comparative analysis of treatment results of the different groups of patients with obliterating disease of the lower extremities vessels.

Experimental study of low level laser radiation effects on human blood cells.

Siposan D, Adalbert L (Bucharest, Roumania).

Fresh blood from 40 apparently healthy individuals has been irradiated with a low level HeNe laser, using EDTA anticoagulant. Doses ranged between 0-54 J/cm2. The authors watched the relative variation to the received doses of hemoreological constants -

erythrocytary and leukocytary indices, as well as the variation of some erythrocytary aggreagability indices-viscocity, BSR. Following irradiation a lowering of the erythrocytary aggreagability (viscosity), BSR, and changes of some erythrocytary and leukocytary indices have been observed. The effect of low-level laser radiation on the red cell confirms the non-resonant mechanism of this bio-stimulating radiation effect by the changes in the cell membrane, in our case the blood cells, by revitalizing the red blood cell functional capacities and by several biochemical effects on the membrane level, that are to be studied thoroughly in future studies. It is concluded that the physical-biochemical and biological effects on blood can influence the physical-chemical parameters needed for long storage of blood products as well as the quick revitalization of the erythrocytary membrane aggressed physically and biochemically, in order to perform its oxophoric function in transfusion procedures.

Vopr Kurortol Fizioter Lech Fiz Kult. 2003 Jul-Aug;(4):10-3.

[Efficacy of laser therapy in patients with ischemic heart disease]

[Article in Russian]

Vasil'ev AP, Strel'tsova NN, Senatorov IuN.

Modification of erythrocytic membrane and the trend in clinicofunctional indices were studied in 93 patients with angina of effort (FC i-IV) in the course of treatment with laser radiation (group 1) and imitation of laser radiation (group 2). In patients of group 1 the treatment resulted in stabilization of cell membrane accompanied with positive cardiodynamic changes.

:Klin Lab Diagn. 2001 Dec;(12):22-4, 33.

[The role of erythrocyte rheological determinants in the regulation of bloodflow structure]

[Article in Russian]

Katiukhin LN.

Correlations of rheological determinants of the erythrocyte viscous characteristics were studied in normal subjects and coronary patients treated traditionally and with photohemotherapy. A rigid relationship between erythrocyte deformability and aggregation was detected in the patients. Blood exposure to He-Ne laser and UV is a potent method for correcting the blood rheology. Physiological significance of the rigid relationship of erythrocyte deformability and aggregation consists in the maintenance of the structure of flowing blood, characteristic of its native status, and represents an additional mechanism of realization of the adaptive potential of blood viscosity regulation in mammals.

J Photochem Photobiol B. 2004 Mar 19;74(1):7-12.

A comparative study of 632.8 and 532 nm laser irradiation on some rheological factors in human blood in vitro.

Mi XQ, Chen JY, Cen Y, Liang ZJ, Zhou LW.
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The effects of laser irradiation with 632.8 and 532 nm on rheological properties of blood were comparatively studied in vitro. Under the irradiation condition of 30 mW, laser irradiation of blood samples using a spot diameter of 5 mm with each laser, showed promising results in the modulation of hemorheological properties. When blood samples from patients with abnormally high values of erythrocyte sedimentation rate (ESR) were irradiated, the values of ESR were lowered statistically by either of the 632.8 or 532 nm lasers. The laser irradiation reduced blood viscosities at different shear rates (10-110 S(-1)) for the hyper-viscosity blood samples. Laser irradiation increased the electrophoretic mobility (EPM) of erythrocytes when the values of the sample's EPM were abnormally slow. The erythrocyte deformability was enhanced by laser irradiation when the deformability of the sample from the patients was originally poor. For verifying the improvement of laser irradiation on erythrocyte deformability, the typical erythrocyte samples with poor deformability were produced by the pre-treatment of the erythrocytes with Ca(2+). The deformability of these erythrocyte samples was also improved after laser irradiation. These results suggest that membrane-bound hemoglobin (Hbm) might be the initial site of the interaction, since Hbm is the main cause of poor deformability when erythrocytes were treated with Ca(2+). In all experiments including ESR, blood viscosity, EPM and erythrocyte deformability, the 532 nm laser demonstrated more efficient effects on modulating rheological properties than 632.8 nm laser. This wavelength effect is consistent with the absorption spectrum of hemoglobin, reflecting that hemoglobin may be one of the action targets under laser irradiation

Vopr Kurortol Fizioter Lech Fiz Kult. 2008 Jan-Feb;(1):15-8.

[Influence of laser radiation of the whole blood in vitro on adhesion and aggregation of blood platelets]

[Article in Russian]

Brill' GE, **Budnik IA**, **Gasparian LV**, **Shenkman B**, **Savion N**, **Varon D**.

The authors revealed dependence of reaction blood plates to photoeffect on the dose and rate of blood movement at laser radiation of donor blood in vitro. The red light decreases adhesion and aggregation of blood plates both at high and low rate of shift. Infrared laser radiation is effective only at high rate of shift leading to increase of adhesion and decrease of aggregation of blood plates. Blue laser is effective in small doses only and at low rate of sift it leads to decrease of adhesion and at high rate it provokes increase of adhesion. Blue laser do not have a significant influence on aggregation of blood plates.

These results make possible to suppose ambiguity of biological response of venous and arterial blood to radiation.

Klin Med (Mosk). 2006;84(2):61-4.

[The influence of low-intensive laser therapy on the aggregation properties of thrombocytes in patients with peptic ulcer]

[Article in Russian]

Burduli NM, **Gutnova SK**.

The purpose of the study was to evaluate the influence of low-intensive laser therapy (LILT) on the aggregation properties of thrombocytes in patients with exacerbation of peptic ulcer (PU). The subjects, 111 patients aged 18 to 63, were divided into two groups: the main group (n = 81), and the control group (n = 30). In addition there were 15 healthy people who also underwent examination. Patients in the main group received complex treatment with untiulcer drugs and different methods of laser therapy: intravenous laser irradiation of blood, cutaneous irradiation, and a combination of both. The control group was treated with drugs only. The study found various changes in the aggregation properties of thrombocytes in patients with PU exacerbation, which consisted mostly in hyperaggregation. LILT had a normalizing effect on the aggregation properties of thrombocytes in patients of the main group.

J Photochem Photobiol B. 2005 Apr 4;79(1):43-50. Epub 2005 Jan 13.

The effect of green laser light irradiation on whole blood platelets.

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BACKGROUND: Laser light irradiation is assumed to have biostimulating effect in various cell types. However, there is still a lack of information concerning response of blood platelets to laser light irradiation. METHODS: In our study we used flow cytometry to monitor the effect of a green Nd-YAG laser (532 nm, 30 mW) irradiation on platelet activation and the expression of activated GPIIbIIIa glycoprotein complex (fibrinogen receptor) of whole blood platelets stained with fluorolabelled monoclonal antibody PAC-1. Also the formation of platelet microparticles and aggregates in a population of whole blood platelets following such irradiation was evaluated. RESULTS:

Effects of laser light on platelet activation and reactivity were significant over a wide range of applied energies ($p<0.01$). While low and medium laser light energies (18 and 54 J) increased platelet activation, the irradiation with a high-energy laser light (108 J) resulted in depressed platelet reactivity and attenuated platelet response to activators. In addition, laser light irradiation had significant influence on the formation of platelet microparticles in either resting ($p<0.05$) or ADP-activated ($p<0.05$) platelets, while no significant effect was observed in collagen-activated platelets. On the other hand, laser light irradiation significantly increased the formation of platelet aggregates both in resting ($p<0.01$) and agonists-activated ($p<0.05$) platelets. CONCLUSIONS: Our results clearly point that the laser light irradiation of blood platelets can trigger signal transduction, leading to platelet activation, as well as the gradual loss of natural platelet reactivity and platelets' ability to respond to activating agents.

Klin Med (Mosk). 2004;82(8):34-7.

[Platelet aggregatory impairments in chronic obstructive bronchitis and a role of laser therapy in their correction]

[Article in Russian]

Burduli NM, **Aksenova IZ**.

A comparative follow-up was made to study platelet aggregatory function in patients with chronic obstructive bronchitis (COB) prior to and following treatment. The patients were divided into study and control groups. In addition to conventional treatment, the patients of the study group received laser therapy as intravenous blood irradiation. According to the type of baseline platelet aggregatory changes, all the patients were divided into 3 subgroups: 1) patients with hyperaggregation; 2) those with normal aggregation; and 3) those with hypoaggregation. In the patients from the study group, the performed treatment corrected platelet aggregatory disorders--the degree of aggregation decreased from 78 +/- 8.6% to 56.8 +/- 6.9% in Subgroup 1, increased from 23 +/- 4.8% to 54.6 +/- 6.21% in Subgroup 3. The similar positive changes in aggregation rates and the cumulative aggregation index was observed in the study group. In the control group, conventional drug therapy caused no substantial changes in platelet aggregatory function. Thus, intravenous blood laser irradiation is an effective technique in correcting thrombocytic dysfunction in COB.

Thromb Haemost. 2001 Oct;86(4):1087-93.

Alterations of platelet aggregation kinetics with ultraviolet laser emission: the "stunned platelet" phenomenon.

Topaz O, **Minisi AJ**, **Bernardo NL**, **McPherson RA**, **Martin E**, **Carr SL**, **Carr ME Jr**.

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Platelets, a major constituent of thrombus, play a crucial role in the pathogenesis of acute ischemic coronary syndromes. The effect of ultraviolet laser emission on platelets within thrombi is unknown. The effects of increasing levels of laser energy on platelets in whole blood were investigated. Blood samples were obtained by aseptic venipuncture and anticoagulated with 3.8% sodium citrate. Samples were exposed to increased levels (0, 30, 45, 60 mJ/mm2; 25 Hz) of ultraviolet excimer laser fluence (308 nm wave-length) and then tested for ADP and collagen induced platelet aggregation, platelet concentration, and for platelet contractile force (PCF) development. Scanning electron microscopy was used to detect laser induced morphologic changes of platelets and by flow cytometric analysis to detect changes in expression of platelet surface antigens p-selectin (CD 62) and glycoprotein IIb/IIIa (CD 43). Exposure to excimer laser energy produced dose dependent suppression of platelet aggregation and force development ("stunned platelets"). ADP aggregation decreased from 8.0+/-1.1 Ohms (mean+/-SEM) to 3.7+/-0.8 Ohms ($p<0.001$) to 2.7+/-0.6 Ohms ($p<0.001$) and to 1.8+/-0.5 Ohms ($p<0.001$) as the laser energy increased from 0 to 30 to 45 to 60 mJ/mm2, respectively. Collagen induced aggregation decreased from 21.4+/-1.4 Ohms to 15.7+/-1.2 Ohms ($p<0.001$) to 11.7+/-1.1 Ohms ($p<0.001$) and to 9.9+/-1.0 Ohms ($p<0.001$), in response to the same incremental range of laser energy. Platelet contractile forces declined from 34,500+/-3700 to 27.800+/-2700 dynes as laser energy increased from 0 to 60 mJ/mm2 ($p<0.03$). Platelet concentration did not change with increasing laser energy. The expression of platelet surface antigen p-selectin (CD 62) remained stable through increasing levels of laser energy exposures while the percentage of CD 43 positive platelets significantly increased with exposure to laser energy, yet the level of expression did not exceed 0.5% of cells. Thus, aggregation kinetics are altered in platelets exposed to ultraviolet laser energy as manifested by decreased platelet aggregation and reduction in platelet force development capability. The response is dose dependent and most pronounced at higher energy levels such as 60 mJ/mm2.

Platelets. 2000 Mar;11(2):87-93.

Blood irradiation by He-Ne laser induces a decrease in platelet responses to physiological agonists and an increase in platelet cyclic GMP.

Brill AG, **Shenkman B**, **Brill GE**, **Tamarin I**, **Dardik R**, **Kirichuk VF**, **Savion N**, **Varon D**.

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The effect of He-Ne laser irradiation on platelet adhesion, activation and aggregation was investigated. Citrated whole blood was irradiated in vitro by He-Ne laser (632.8 nm, 7 mW) and then subjected to shear stress (1300 s-1) on subendothelial extracellular matrix (ECM)-coated plates. Laser irradiation was followed by a decrease in platelet adhesion and aggregation on ECM under flow conditions in a time exposure-dependent manner (by 30-40%). The inhibiting effect of laser light on platelets was detectable up to 1 h after the termination of irradiation. Laser irradiation of either platelet-rich plasma, gel-filtered platelets, platelet-poor plasma, or packed blood cells followed by whole blood reconstitution revealed a marked decrease in platelet deposition on ECM only in the cases of platelet-rich plasma or gel filtered platelets. In conventional aggregometry, laser-treated platelet-rich plasma demonstrated a diminished platelet response to both thrombin receptor-activating peptide (TRAP), converting a two-wave aggregation curve to reversible, and to the protein kinase C activator PMA (by 45%). In flow cytometry analysis, irradiated platelets presented lower fibrinogen binding and P-selectin expression in response to TRAP. Laser irradiation had no additional inhibitory effect on dibutyryl cGMP- and dibutyryl cAMP-pretreated platelets. A 50% increase in cGMP level was observed in laser-treated gel filtered platelets, both in the presence and in absence of the phosphodiesterase inhibitor, isobuthylmethylxanthine. The results suggest that guanylate cyclase is one of the primary mediators of the laser effect on platelet function.

Cell Biol Int. 1998;22(3):245-8.

The biostimulatory effect of red laser irradiation on pig blood platelet function.

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Department of Biophysics, University of Lodz, Poland.

The molecular mechanisms of laser-induced changes in the cell structure and function are not well known. The authors examined the effects of low-power laser irradiation on unnucleated pig blood platelets. The obtained results showed that laser irradiation (1-5 J) caused in blood platelets lipid peroxidation (measured as thiobarbituric acid reactive substances) and superoxide anion generation, concomitant with the release of adenine nucleotides and proteins from platelets. The maximum platelet response to laser irradiation was observed when doses of 1.8-2 J were used. Our results indicate that red laser irradiation induces: (1) platelet secretory process and the release of substances stored in the specific granules (adenine nucleotides, proteins); and (2) lipid peroxidation partly due to stimulation of endogenous arachidonate and production of its metabolites reacting with thiobarbituric acid.

Am Heart J. 1993 Feb;125(2 Pt 1):357-62.

Laser-induced stimulation of thromboxane B2 synthesis in human blood platelets: role of superoxide radicals.

Arora RR, **Mueller HS**, **Sinha AK**.

Department of Medicine, Columbia University College of Physicians and Surgeons, New York, NY.

Exposure of platelet-rich plasma to laser radiation at 3.5 W for 30 seconds reduced the threshold concentrations of adenosine diphosphate and L-epinephrine needed from complete platelet aggregation by 20% to 60% and by 30% to 50%, respectively. The irradiation of platelet-rich plasma with laser also increased the basal level of thromboxane A2 from < 0.5 pmol/10(8) platelets for each second of exposure. In contrast, the exposure of gel-filtered platelets to laser produced no effect on the prostanoid formation. However, the addition of laser-exposed platelet-free plasma to gel-filtered platelets stimulated the synthesis of thromboxane A2 in these cells. The effect of laser was completely blocked by adding superoxide dismutase or catalase to the platelet-rich plasma, indicating that the radiation-induced stimulation of thromboxane A2 production was mediated through the generation of superoxide radicals. Electron microscopic studies indicated that the laser-induced stimulation of thromboxane A2 production in platelet can occur without any noticeable damage in the cellular structure.

Lasers Surg Med. 1988;8(3):259-63.

Carbon dioxide laser effect on platelet function and surface ultrastructure in vitro.

Eldar M, **Gal D**, **Djaldetti M**, **Douer D**, **Rosner E**, **Katzir A**, **Neufeld HN**, **Battler A**.

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Platelet aggregation may be an important factor in the feasibility of transcatheter laser angioplasty. The in vitro effects of increasing doses of CO2 laser irradiation on platelet number, function, and surface ultrastructure were examined. Results indicated a progressive dose-response reduction of both platelet number and function following laser irradiation. By scanning electron microscopy the irradiated platelets showed dose-related changes in pseudopods as well as progressive damage of the cell membrane.

Thromb Res. 1988 Jun 1;50(5):657-67.

The effects of argon laser on in vitro aggregation of platelets in platelet rich plasma and whole blood.

Doerger PT, **Glueck HI**, **McGill M**.

Department of Pathology, University of Cincinnati College of Medicine, Ohio.

The effects of an Argon laser on platelet aggregation were studied, since platelets may be exposed to laser energy when used intravascularly. Various preparations of platelets in platelet rich plasma (PRP) and whole blood, with or without aspirin, were tested with the aggregating agents ADP, collagen, thrombin, and epinephrine. Simultaneous release of ATP was also measured in PRP. At relatively low levels of irradiation, platelet aggregation was potentiated. Enhancement was evidenced by an increase in percent aggregation, earlier onset of the reaction, and reduction in the amount of aggregating agent required. In PRP, the mechanism of laser potentiation appeared to be the release of endogenous ATP from platelets. At relatively high levels of irradiation, platelets were destroyed and aggregation abolished. In whole blood, the mechanism was somewhat more complicated since release of ATP occurred from RBCs as well as platelets. Spontaneous aggregation following laser treatment occurred in isolated instances in PRP and in every trial in whole blood preparations. Aspirin ingestion inhibited the laser's effects in PRP but not in whole blood. These results may have important clinical implications for laser angioplasty, and the potentiated aggregation response may prove useful in laboratory studies of platelet function.