The Phenomenon of Laser-Induced Oxyhemoglobin Photodissociation and its Biomedical Application

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Abstract— The results of experimental in vivo investigation the phenomenon of blood oxyhemoglobin photodissociation are presented. Novel technology of tissue oxygenation due to additional oxygen extraction is developed. A significant increase in tissue oxygen concentration directly at the irradiating zone by laser radiation is obtained. Different biomedical applications of the effect of laser radiation on gas exchange processes in biological tissue are discussed.

Oxygen plays a key role in aerobic cell metabolism. The concentration of oxygen delivered through blood microcirculation is critical for normal cell metabolism as it must be delivered in adequate amounts for normal functioning.

Reduction in the volume of blood microcirculation in biological tissue (ischemia) or decreasing the concentration of oxyhemoglobin in arterial blood induces hypoxia. Improving tissue oxygenation and elimination of local hypoxia continues to be a problem in modern medicine.

In this report, a new approach in solving the problem of eliminating local tissue hypoxia based on laser-induced photodissociation of blood oxyhemoglobin is discussed. The results of in vivo investigation of additional oxygen extraction due to oxyhemoglobin photodissociation are presented. A significant increase in tissue oxygen concentration directly at the irradiating zone by laser radiation is obtained. The efficiency of laser-induced tissue oxygenation is comparable with the method of hyperbaric oxygenation (HBO) at the same time gaining advantages in local application.

Laser-induced photodissociation of HbO₂ gives a novel and unique method to optically increase the local concentration of free molecular oxygen in tissue which significantly enhances cell metabolism. Taking into account the fact that blood delivers O₂ to any cell tissue and that cell metabolism requires consumption of oxygen we suggest to establish the therapeutic effect of laser radiation based on controlling summary tissue oxygen concentration.

It is shown that in order to make phototherapy as well as laser therapy methods really efficient one has to control the oxygen concentration in tissue keeping it at the necessary level. This goal can be achieved by the use of the phenomenon of laser-induced photodissociation of oxyhemoglobin in blood vessels.

Additional oxygen extraction stimulates cell metabolism and allows development of new effective methods for laser therapy as well as phototherapy of pathologies where elimination of local tissue hypoxia is critical.

The proposed method aimed at optimization of therapeutic efficiency laser radiation effect is based on using the change in oxygen concentration as a feedback signal.

Laser induced photodissociation of HbO₂ allows to extract additional amount of oxygen locally at irradiating zone. This phenomenon provides a unique possibility to use optical methods for regulation of local tissue O₂ concentration.

Novel method of optical “dosimetry” based on using the changes in tissue oxygen concentration as a feedback signal for the optimization of low intensity laser radiation therapeutic effect has been developed.

Different biomedical applications of the effect of laser radiation on gas exchange processes in biological tissue are discussed.