Optical Method and Devices for Elimination of Carbon Monoxide Toxic Effect on Human Body

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The problem of effectively eliminating the toxic effect of carbon monoxide is an urgent and socially significant task. Up to the present, the capabilities of modern medicine remain quite limited and therefore losses as a consequence of poisoning are serious.

Presently we proposed and developed optical method of elimination the toxic effect of carbon monoxide based on the phenomenon of laser induced photodecomposition of blood carboxyhemoglobin - HbCO.

It is well known that gas carbon monoxide (CO) forms strong bind with blood hemoglobin (Hb) The decay rate of HbCO complexes is extremely low, and at it concentration in the blood about 20%, the period of its half decay time takes more than eight hours.

For elimination of poisoning effect of CO in clinical practice usually uses ventilation of lungs with pure oxygen. This method is used usually in the cases no strong intoxication, but at concentrations of HbCO in the blood higher than 60% it becomes useless.

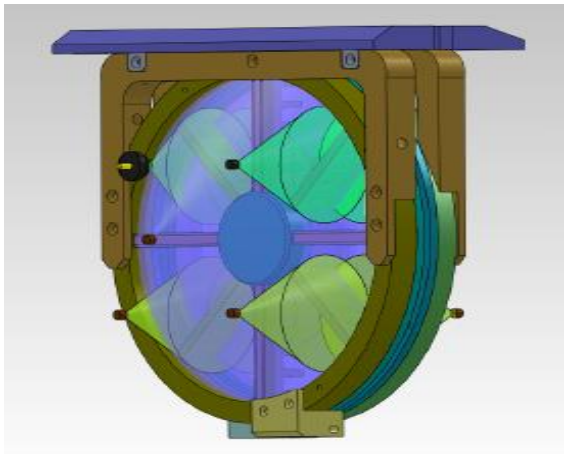
Currently, the method of hyperbaric oxygenation (HBO) based on the effect of pure oxygen on human body at the pressure of several times higher than atmospheric is used for detoxification. The method of HBO increases the concentration of oxygen in the blood and at the same time results a higher risk of oxygen toxemia. Thus, the problem of eliminating the toxic effect of CO remains urgent and solving it requires new approaches to developing modern, highly effective therapeutic methods.

We proposed and developed an optical method for eliminating the toxic effect of carbon monoxide, which is based on laser induced photodecomposition of blood HbCO (Asimov M.M., Asimov R.M., Rubinov A.N., “Method of deactivation of blood carboxyhemoglobin”, //Patent, №2408400. 2011).

In addition to this, photodissociation of carboxyhemoglobin makes it possible to restore hemoglobin’s function of transporting oxygen to tissue cells. Despite the fact that the bond in the CO complex with Hb is significantly stronger than in the case of O2 complex with Hb, the effectiveness of photodissociation of HbCO is almost an order of magnitude higher than HbO2: 98 and 10% in the visible range of the spectrum, respectively [6]. Such a large difference in the quantum yield of photodissociation opens the possibility of destroying the blood HbCO complex with high selectivity, essentially not touching the useful HbO2 component. At the same time as the effectiveness of known methods of eliminating the toxic effect of CO is limited by the time of natural decay of the HbCO complex, mandatory destruction of HbCO by photodissociation under simultaneous saturation of the blood plasma by molecular oxygen makes it possible to substantially hasten the removal of CO from the body.

The basis of the suggested method is irradiation of blood vessels and capillaries by optical irradiation of a certain wavelength. As well, the majority of energy absorbed by blood HbCO will be expended on photodissociation. We present here the results of investigation the effect of optical radiation with HbCO in cutaneous blood vessels and capillaries and the method of its effective photodissociation.

On the basis of research results, obtained both in the numerical simulation of the interaction of laser radiation with blood HbCO and experimental measurements in vivo it is developed the apparatus for phototherapy the poisoning effect of carbon monoxide (see photo).

This apparatus provides in vitro irradiation of blood by optical radiation in the wavelength range of 530 – 560 nm. Wavelength and the output power of the radiation chosen in accordance with the maximum of absorption bands of blood HbCO.

The device has the following main specifications:

• Operation mode setting time installation after the inclusion of not more than 5 min.

• The speed of the flow of the blood of 5, 10 and 15 ml/min.

• Accuracy of flow rate of blood is no more than + / 20 %.

• Spectral range of the radiation from 530 to 630 nm.

• Time of continuous work of the installation is not less than 8 hours.

• Information on the modes of operation of the installation is displayed on the alpha-numeric display.

• Power supply voltage 230 ± 22 Century, with frequency of 50 Hz.

• Power consumption is not more than 80 VA.

• Overall dimensions not more than 260 × 250 × 143 mm.

• Weight of installation of not more than 7 kg.

Apparatus for extracorporeal blood irradiation is a compact device with three main modules: a spiral cassette with a sample of blood irradiation; peristaltic pump for blood circulation and the optical system, which provides two-side blood irradiation with LED sources. Light sources are selected in accordance with the maximum of absorption bands of blood HbCO in the visible spectral range. Apparatus is equipped with the system of protection against removing the cassette during the work.

In this apparatus a planar LEDs with the selected spectral range and the output power of radiation is used. The algorithm of operation of the apparatus provides selective activation and deactivation of each LEDs that allows one to vary the different parameters of the light effects (such as the pumping wavelength of light, or a combination of wavelengths, optical radiation power, etc.) to achieve the desired therapeutic effect. It is also possible increase or decrease in the «dose» of exposure by changing the speed of pumping blood.

Developed apparatus for extracorporeal blood irradiation on the bases of the phenomenon of laser induced carboxyhemoglobin photodissociation may find wide application in modern medicine and could also be useful in emergency situations in elimination the consequences of fires or anthropogenic disasters.