

A PATHOGENETIC RATIONALE FOR CLINICAL USE OF LOW-INTENSIVE OPTIC-SPECTRUM RADIATION IN CHILDREN

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With increasing adverse exogenous and endogenous impacts on human health, a major line of improving medical care is the search for new effective methodologies of restoring impaired homeostatic mechanisms in a diversity of diseases. One of these is low-intensive optic-spectrum electromagnetic radiation. Used alone or in a weak static magnetic field, this radiation has information and energy effects on body tissues in different diseases which are difficult to treat with conventional interventions. The effects occur as intricate mechanisms of body autoregulation at atomic, molecular, subcellular, cellular and organic levels, resulting in normalization of impaired systemic adaptation.

This concept is based on general effects of sunlight on biological subjects and pathogenetic patterns of diverse conditions of children and adults.

It is known that man-made environmental pollution, mechanical or thermal injury, acute or torpid inflammation and degenerative processes, especially when they are concurrent with "light deprivation", impair complex adaptive mechanism of cellular homeostasis whose normalcy rests on structural conformation of cell membranes which have a liquid-crystalline structure. Pathophysiological changes in information and energy relations resultant from these adversities in turn affect phase transitions of the cellular and intercellular fluid, stopping them at the crystallization phase. Therefore, the dynamic structuring of body tissues is impaired. Our earlier clinical and cytohistochemical studies in chronic bronchitis have shown that water-insoluble mineral substances which cement destroyed tissue and cellular elements precipitate at sites of aseptic, allergic, specific or purulent inflammation (Biryukov, Balandina, Gatkin, 1990; Gaidashev et al., 1992). Regenerative processes are dramatically hindered or stopped because of mass death of cells which mediate primary immunity or their transition to an anabiosis-like state of active rest (Gaidashev and Novikov et al., 1992; 1994). Disease progress becomes torpid: bone fractures, scalping, thermal or operative wounds won't heal, and trophic or necrotic mucosal lesions progress.

To cope with this critical state in conditions of hypoxic impairment of redox reactions, which mediate energy spending, the body recruits an alternative, but imperfect mechanism of deriving energy from lipid peroxidation. Toxic effects of underoxidized metabolic products on cell membranes cause their destruction and further affect the already compromised repair processes. Consequences of "peroxide stress" are most prominently brought out by aggressive, combined drug treatment which is common these days and which not infrequently results in fatalities or iatrogenic "drug disease".

Therefore, the concept outlined above suggests that a promising intervention is biostimulation of metabolic processes by isolated or combined use of low-intensive optic-spectrum electromagnetic radiation with different characteristics. Coherent monochromatic red light generated by the helium-neon laser meets this task best, but its clinical use is restricted because it is cumbersome.

One of best-designed new generation lasers is MILTA, a semiconductor therapeutic device which generates low-intensive coherent and incoherent infrared radiation in a weak static magnetic field (35 ± 10 mT) having no damaging effects on tissues. The use of MILTA can appreciably enhance the efficacy of biostimulating therapies in various areas of medicine, including pediatrics.

However, laser treatment has not found extensive applications in pediatric care because effects of photon and magnetic energy on disease progress in children have been inadequately evaluated. Standard validated medical technologies which would use feedback electronic optic hardware are also lacking. This prompts a look at the rationale for and safety of laser therapy in pediatrics.

The goal of this study was clinical and laboratory validation of the use of low-intensive photon and magnetic energy for restoration of disturbed self-regulation of cellular and systemic homeostasis in children with acute and chronic diseases.

Materials and Methods

Red and infrared laser therapy and magnetic infrared laser therapy was added to conventional conservative and surgical treatment of over 4,000 children with burns, abdominal diseases, acute and chronic bronchopulmonary and uronephrological diseases. Three to seven treatments with an exposure of 60 to 300 seconds were usually given. A third of cases required three-five additional courses of photon therapy. In 205 children, paraclinical control of therapy included cytohistochemical studies of tissue detritus from the wound or bronchi, a Rebeck skin window test of the nonspecific cellular response, follow-up biomicroscopic studies of systemic microcirculation using photographic imaging of eye bulb vessels with rapid diagnosis and subsequent digital morphometry of film negatives, and tests of blood prooxidant and antioxidant enzymes. External respiration was evaluated by mass-spectrometric gas analysis. Blood gases, blood partial oxygen and carbon dioxide pressure, hemoglobin, oxyhemoglobin and oxygen saturation were measured.

Results and Discussion

This study presents experience with low-intensive laser radiation (LILR) in pediatrics and pediatric surgery. The empirical results were seen as a clinical response and laboratory findings reflective of intricate interactions of LILR with the body in the presence of disease. Since their indepth interpretation is hardly possible at the current phase of photobiology and medicine, we probed into the mechanism by which laser energy shapes the wave field in body tissues. The sheerly pragmatic question was whether this physical factor can be used to change the fluid-crystalline structure of water-insoluble tissue detritus at a chronic inflammation site in order to restore transcapillary gas exchange and dynamic conformation of cell membranes and move the torpid purulent necrotic process "from the dead ground".

Even intensive conventional drug treatment of a purulent focus is not uniformly effective because it does not purport to recruit host mechanisms of wound debridement, restoration of cell and tissue organ specificity and normalization of repair processes.

Given that defective molecules of tissue detritus at an inflammatory site can show little conformational difference from normal ones but can be much different in their phase state, we appreciated the very fact that LILR induced disintegration of solid tissue detritus at a chronic inflammation site.

Thus a study of Balandina has shown that extracellular substances which are part of tissue detritus are water-insoluble, solid viscous aggregates of neutral lipid, phospholipid and lipoprotein compounds, lipid crystals and calcifications. Physico-chemical properties of these aggregates could not be eliminated from bronchial inflammation sites, as they were adhesive and strongly fixed on the affected mucosa. With laser therapy, the aggregates became loose, fine granular and less tightly attached to the mucosa. The viscous aggregates turned water-soluble because their lipid components were replaced by mucopolysaccharides. This allowed to rapidly eliminate tissue detritus from bronchi and shortened treatment two-three times. Conversion of lipid crystals to lipid droplets was most descriptive of these changes, and this suggests effects of LILR on physico-chemical properties of fluid-crystalline compounds which consist of glycoproteins, mucopolysaccharides and phospholipids.

This provided us with a starting ground for explaining the activation of functionally passive inflammatory cells. Electron microscopic studies have shown that LILR caused activation structurally intact phagocytes, presenting as compact nuclear chromatin, enlargement of cytoplasm, intensification of vacuolization and an increase in numbers of pseudopodia. A find of special interest were bronchial epithelial cells on imprints of the bronchial mucosa, an indication of restored organ specificity of cells. Concomitantly, bronchial secretions were found to have more mucopolysaccharides which are normally produced by the tracheal and bronchial stratified columnar epithelium.

Therefore, our evidence suggests that low-intensive laser radiation can influence energy-information relationships of adaptive mechanisms with activation of regeneration, a basis of biostimulating effects of this therapy.

Intensification of lipid peroxidation is known to cause an increase in the membrane content of polyunsaturated fatty acids, membrane rigidity and a decrease in membrane ATPase, K, Na, Ca and Mg which mediate electrolyte transport across cell membranes. It is also associated with mitochondrial swelling and metabolic disorders resulting in inactivation of membrane-bound enzymes and mitochondrial lysis.

Our earlier study in patients with acute lobitis, pleuropneumonia, and chronic bronchopulmonary diseases had found a 2.5-fold lower ATPase activity in erythrocyte membranes from children with complicated acute pneumonia. However, ATPase function remained stable and sensitive to a calcium stimulator in vitro. Xanthine oxidase activity was three-fourfold above normal, but superoxide dismutase activity remained within a normal range, suggesting adequate compensatory mechanisms of gas exchange in children with acute pulmonary conditions.

Children with chronic bronchopulmonary diseases also had depressed erythrocyte membrane ATPase levels, but, unlike in the former group, ATPase function was impaired: the enzyme was less sensitive to activating effects of calcium. Xanthine oxidase levels were three- to sevenfold above normal, but the superoxide dismutase activity was depressed twofold. This suggested that other compensatory and adaptive mechanisms were at work in the presence of chronic torpid bronchopulmonary diseases and that tissue gas exchange was affected by local hypoxia, a situation which was managed by helium-neon laser therapy.

We see general effects of LILR on the organism as a manifestation of a nonlinear response of a dissipative nonequilibrium system to a minor, subthreshold stimulation which is called a minor perturbation effect.

As it has been stated above, LILR therapy was controlled by prooxidant and antioxidant testing. Pretreatment xanthine oxidase levels were two-four times above normal. A mean 20 percent decrease was seen after five-six LILR treatments, as against eight percent in the control group. Levels of catalase, a "tissue protection" enzyme, were increased by laser therapy by a mean 40 percent in patients and remained unaltered in the control group. These enzyme changes were indicative of an antioxidant effect of LILR and of a generalized response to local laser therapy. A combined methodology of magnetic laser therapy adopted in the clinic of Pro. Gaidashev was used in management of children with bronchopulmonary diseases. The combined use of the weak static magnetic field, low-intensive infrared laser radiation and incoherent low-intensive infrared diode light produced a prominent clinical response of children with acute lobitis and pleuropneumonia, as the magnetic field has active vascular effects and infrared radiation antiinflammatory effects.

Magnetic laser treatments were accomplished with the MILTA device at three chest projections of inflammation locations. A mean power was 4 mW, frequency 50 Hz and exposure five-six minutes. Apart from the mentioned effects, this exposure was consistent with the ultradian rhythm of chronobiological treatment - both the biorhythm of the integral intracellular contour and blood flow redistribution take five minutes.

External respiration and gas exchange tests significantly improved after five-six treatments. This was demonstrable as 1.5-2-fold improvement of lung diffusion capacity, the ventilation equivalent, oxygen utilization coefficient and blood gas transport as compared with the control group. These findings indicated a fuller recovery of respiratory membrane function after low-intensive magnetic laser therapy.

Effects of low intensive laser radiation on microcirculation have been extensively reported, but evidence of the quantitative and qualitative response of specific capillary compartments to quantum therapy is lacking. Many have stated benefit of this therapy in bronchopulmonary diseases, but no clear guidelines for laser therapy have been generated to date, and reported therapy results remain controversial.

Our joint study with Kazanskaya, Bannikov and Tabakina explored the microcirculatory response to low-intensive magnetic-laser therapy in patients with bronchitis and cystitis - mucosal inflammation of different locations. Microcirculation was assessed by conjunctival microangiography. Inflammation was associated with local and total hypoxia clearly presenting as findings of gas analytical, cytochemical, endoscopic and microcirculation studies.

Since the local inflammatory response is well-known, we will dwell on the general microcirculatory response of patients with local inflammation. All patients were found to have spastic or spastic-atonie microcirculation disorders before therapy: significant or moderate

arteriolar spasticity and increased venular diameters, with a resultant decrease in arteriolar-venular ratios and excessive capillary tortuosity and looping.

Conjunctival microcirculatory disorders rated high on a coefficient table and made a mean 12.5. Capillary blood flow was abnormal in all children, with its granular or even lumpy pattern seen in second- and first-order venules, arterial and venous capillaries. Numbers of small vessels were dramatically reduced in 42 percent of children, excessive in 25 percent and normal in the rest. Microcirculatory disorders were qualified as grade 2 in 58 percent of the patients, grade 2-3 in 8 percent and grade 1 in 8 percent.

Two-three laser treatments significantly improved systemic microcirculation. Capillary tone improved and arteriolar spasticity ameliorated or even reverted, but dilation of second- and first-order venules persisted in about half of the patients. Nonetheless, the inflow/outflow ratio was normal or near-normal in 82 percent of the patients. Abnormal tortuosity and looping of small vessels occurred less frequently.

Venular and capillary flow was homogeneous in 33 percent and remained granular in 58 percent of children after therapy. Conjunctival circulation improved by a mean 50 percent. This presented as a lower grade of microcirculatory disorders. Thus the disorders were absent or their severity subsided to grade 1 in 75 percent of the patients.

After eight-nine treatments, significant microcirculation improvement was seen in all patients, although some abnormalities persisted, which is expectable in patients with severe disease. Thus arteriolar and capillary diameters returned to normal in 25 percent of the patients, moderate dilation of second-order arterioles and venules was seen in 50 percent, and diameters of first-order venules and capillaries returned to normal, all with a near-normal inflow/outflow ratio. Granular blood flow was seen in only a third of examined vessels, while its pattern was normal in the rest. The conjunctival microcirculation coefficient decreased to 5.3. Persisting microcirculatory disorders were grade 0-1 and did not require further correction.

Therefore, magnetic-infrared laser therapy of children with bronchitis and cystitis had a beneficial effect on systemic circulation. Importantly, LILR had a combined effect on microcirculation. On the one hand, it reverted to normal the inflow/outflow ratio in the microcirculation system by improving tone of all small vessels; on the other, LILR had a positive effect on capillary blood fluidity, which is not always achievable by infusion of rheologically active substances. Comparison of LILR and rheological drugs showed advantages of laser radiation, as its effects lasted three to five times longer than those of blood, polyglucine, rheopolyglucine or plasma infusion. This helped a more rapid reversal of inflammation.

Of interest are immunostimulating effects of magnetic-infrared laser therapy in children with different nephropathies. Laser therapy alone using the MILTA device produced a local immune response in children with neurogenic bladder dysfunction and cystic cystitis. The response presented as an increase in the phagocytic index and phagocytosis completion only when these values were low before therapy. Normal pretreatment indices of humoral immunity were not changed by laser therapy. Apart from the immunostimulating effects, normalization of the micturition pattern was seen in these children. Laser therapy of children with acute and chronic glomerulonephritis stimulated phagocytosis concomitantly with abatement of inflammation of most patients. However, renal function impairment was seen in patients with fibrosing glomerulonephritis, presenting as a decline in glomerular filtration rate concurrent with further phagocytosis depression. Therefore, laser therapy of patients with glomerulonephritis is appropriate only when glomerular filtration is normal and clinical evidence of renal fibroplasia is absent.

CONCLUSIONS

Clinical and paraclinical evaluation of biostimulating effects of low-intensive red laser radiation and magnetic-infrared laser therapy in children with intercurrent and surgical diseases indicates beneficial effects of these interventions on adaptive self-regulation of the body in the presence of inflammation. This suggests that the use of laser therapy in pediatrics and pediatric surgery is pathogenetically relevant, effective and safe.

REFERENCES

1. Biryukov V.V., Balandina Y.K., Gatkin Y.Y. Vopr. Okhr. Mat. Det., 1990, 3:11-14
2. Gaidashev E.A., et al. Endobronchial laser therapy of children with chronic nonspecific pulmonary diseases: Guidelines., Moscow, 1992.
3. Gaidashev E.A., Novikov V.N., Verkholtantsev Y.A. Pediatriya, 1992, 1:64-68
4. Gaidashev E.A., Lebedev K.N., Novikov V.N., Zuev V.V., Gnevashev M.M. Abstracts of the National Congress on Respiratory Diseases, Moscow, 1994, 167