Influence of low-intensity electromagnetic fields of endogenous origin on the state microcirculation in the area of the postoperative wound in cardiac surgery patients

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Relevance

The development of science and medical technology allows scientists and clinicians to consider the processes occurring in the human body at a more subtle level. The processes occurring at the cell level are gaining more and more interest. Intercellular interactions, transmembrane ion currents, tissue regeneration are studied. The knowledge accumulated in this area has made it possible to use the electromagnetic fields generated during the life of a cell to control biochemical and physiological processes both in the cell and in the body as a whole. The study of electromagnetic fields (EMF) has shown that low-intensity electromagnetic fields have a special effect, whose effect is tens and hundreds of times greater than the effort expended on the impact. Among other things, close attention is paid to the influence of low-intensity electromagnetic fields on the processes of microcirculation. A number of authors noted that the effect of exposure depends on the parameters of the EMF, such as: wavelength, frequency, magnetic field strength and duration of exposure.

For example, Ichioka et al (2000) [1] found that a static magnetic field (SMF) (up to 8 T) can cause changes in skin blood flow and temperature in mice. After irradiation, microcirculatory blood flow initially increases for 5 minutes, followed by a gradual decrease and returns to control values. An increase in blood flow in skeletal muscles has been shown in response to whole body irradiation with SMP (0.3, 1 and 10 mT for 10 minutes) [2]. Other authors have identified a threshold of 1 mT, at which there is an increase in microcirculation in the muscles of mice under phenobarbital-induced anesthesia. Applying 4 T SMP to volunteers for 15 minutes, Mayrovitz and Groseclose (2005) [3] showed that microcirculation in a resting finger was reduced. Morris and Skalak (2005) [4] showed that SMP (70 mT for 15 minutes) affects the diameter of the arteries in the tonic mode, normalizing blood flow characteristics.

Thus, SMP can be effective in the treatment of many ischemic and edematous tissue disorders involving compromised microvascular functions, because this response occurs initially in resistive arterioles, which significantly affect tissue perfusion. In recent studies, the same authors [5] say that chronic irradiation of the SMP can alter the adaptive microcirculatory remodeling response to mechanical damage. Moreover, other studies show that acute irradiation with moderated MF force reduces the formation of edema in rats [6]. The imposition of 10 or 70 mT, but not 400 mT for 15 or 30 minutes immediately after histamine-induced edema ends in a significant decrease in edema formation by 20-50%. In addition, a 2-hour 70mT irradiation of lambda carrageenan-induced edema also yields a significant (33–37%) reduction in edema. The authors believe that the potential mechanism of action of SMP on vascular tone is due to the effect on L – Ca 2+ channels in vascular smooth muscle cells.

However, despite numerous studies, it was not possible to come to a consensus about the change in the nature of blood flow under the influence of an electromagnetic field (EMF), since both vasorelaxing and vasoconstrictor effects are observed [7].

The studies carried out are based on the fact that the threshold for the action of an alternating magnetic field (PMF) on the microvasculature is an induction of 1 mT [7]. At the same time, induction of 8T led only to a short-term change in microcirculation, which was regarded as a compensatory reaction of the microvasculature to ischemia during irradiation [7]. According to some authors [3, 4], the lack of effect in healthy individuals was associated with the normal vascular tone of the subjects. The direction of the resulting effect depends on the initial state of vascular tone [8]. The regulating action of 1.5 and 10 mT of PMP was shown [9] and at 70 mT [10].

Thus, the effects of EMF are determined by both the field parameters and the properties of the biological object, in particular, by the initial state of vascular tone, and the maximum modulating effect on vasomotor functions is exerted by moderate EMF intensities. At the same time, it can be noted that the effect is exerted by both static electromagnetic fields and pulse ones. This example suggests that it is quite difficult to draw the border between the PEMP, SMF and EMF, since the effect will depend on the hit of the frequencies used in the correct resonant (coherent) frequencies of the required biological system [11].

Our interest in low-intensity electromagnetic fields is due to the need to correct functional changes in blood flow at the level of microcirculation in cardiac surgery patients.

Materials and methods

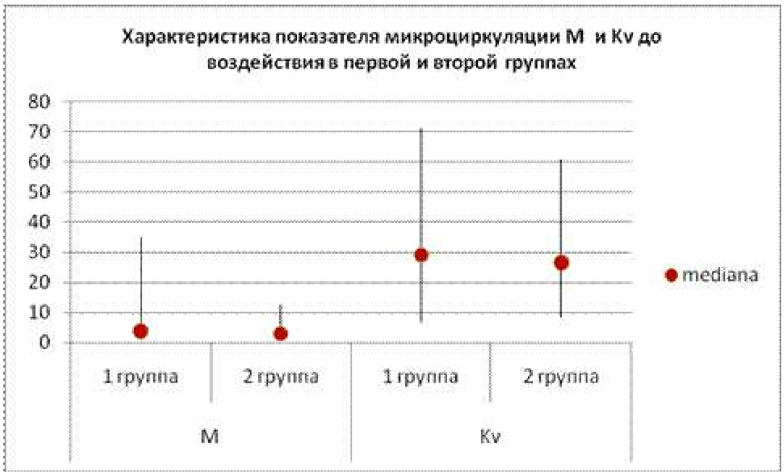
The objects of the study were patients with cardiovascular diseases who underwent surgical treatment in conditions of cardiopulmonary bypass. Patients (n = 92) aged 18 to 65 years (37 ± 16) were divided into 2 groups: group 1 - patients treated for congenital and acquired heart defects; Group 2 - patients with coronary artery disease, atherosclerotic lesions of the coronary vessels - this category of patients underwent coronary artery bypass grafting. The impact of EMF was carried out on the hardware and software complex "IMEDIS-EXPERT" (Russia). The frequency characteristics of the produced field depended on the initial endogenous field of the subject, were automatically selected using the APC, but fit into the range of 10–500000 Hz. The intensity of the electromagnetic field of the device was 0.2 mT; operating mode - therapy / pause - 3: 1; exposure time of one frequency range - 1 second; the duration of therapy was 5 minutes. A loop magnetic therapy device was positioned in the postoperative wound area over a sterile dressing. The dynamics of the state of the microvasculature in the area of the postoperative wound was investigated when exposed to low-intensity electromagnetic fields of endogenous origin.

The study of microcirculation was carried out in the area of the skin wound, at a distance of 1 cm from the suture line. We used a device for laser Doppler fluometry LAKK-02 (NPO Lazma, Russia) with a source of short-wave radiation in the red region of the spectrum of 0.63 μm. Such indicators of blood flow as M - the value of the mean blood flow (PM) in the recording time interval (measured in perfusion units - pf.units) were evaluated. - standard deviation characterizing the temporary variability of perfusion, reflecting the modulation of blood flow in the microvasculature, which occurs with a temporary change in the lumen of the vessels. In the analysis of the calculated data, we were guided by the ratio of the values of M and σ, that is, by the coefficient of variation: Kv = σ / M x 100%. We also evaluated: NT-neurogenic tone, which characterizes the frequency of neurogenic fluctuations, MT - myogenic tone, which characterizes the frequency of myogenic oscillations, and PS - shunting index, which characterizes the MT / NT ratio. Subsequent calculations were performed using a wavelet transformation on a computer using the program for recording and processing blood microcirculation parameters, version 2.2.510.512 (16.02.2010). The data obtained were evaluated according to the classification of microcirculation types proposed by V.I. Makolkin. [12]. Statistical processing was carried out by parametric and nonparametric methods. P <0.05 was considered significant.

Results and discussion

Our studies have shown that the initial state of the microvasculature in the area of the postoperative wound is very diverse. For example, the median M in the first group was 3.67 pf. Unit (p (SW) <0.001) minimum - 0.75 pf.units, maximum - 34.99 pf.units. In group 2 patients, the median M was 2.93 pf Units, (p (SW) <0.001), the minimum value was 0.66 pf units, the maximum value is 12.75 pf units. In this case, the median Kv for the first group is 29.12 pf. units (p (SW) <0.004), the minimum value is 6.59 pF. units, the maximum value is 71.00 pf units, and for the second group, the median Kv was 26.56 pf. units (p (SW) <0.11), the minimum value is 8.39 pF. units the maximum value is 60.86 pf. units

Thus, the studies carried out to study the state of the microvasculature in the area of the postoperative wound showed the predominance of low values of the microcirculation index M in both groups 1 and 2, which indicates a spastic type [12] of capillary blood flow in the area under study (Fig. 1).

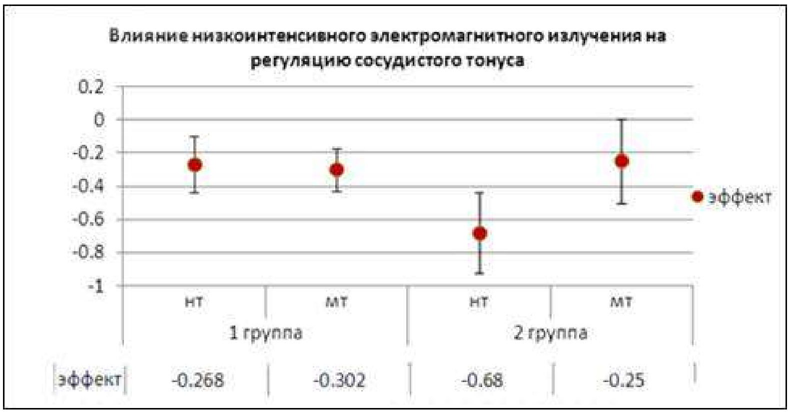


Rice. one.Characteristics of the index of microcirculation M and Kv before exposure in the first and second groups

Evaluating the variability of the microcirculation index M, one can see that in the second group, in patients with ischemic heart disease, atherosclerotic lesions of the coronary vessels, the variation of this sign is less, which indicates a more pronounced vascular dysfunction (Fig. 1).

Under the influence of a low-intensity electromagnetic field for 5 minutes, there was no significant change in the microcirculation index - the M effect in the first group was 0.39, the M effect in the second group was 0.12.

Evaluation of changes in the mechanisms of regulation of microvascular tone showed that in the first group, EMF has a greater effect on myogenic tone (MT effect = -0.302 ± 0.13, p = 0.021), in the second - on neurogenic tone (NT effect = -0.68 ± 0.242, p = 0.024) (Fig. 2).



Rice. 2.Influence of low-intensity electromagnetic radiation on the regulation of vascular tone

At the same time, the shunting index (PS) after exposure to EMF was significantly reduced in the first group (it was slightly reduced before exposure), the average effect of PS from EMF in group No. 1 is small and negative (ΔPS = -0.05), and in group 2 it is positive (ΔPS = 0.18) and the difference in effects is statistically significant p (U) = 0.009. To test the hypothesis about the relationship between the effect of EMF exposure and the initial state of microcirculation, a correlation analysis of the relationship between the initial values of the studied signs and the effects of using EMF in both groups was carried out. As a result, it was revealed that the correlations between the initial values and the effects of the use of EMF in both groups of patients for indicators M are negative and rather high, which suggests that there is a tendency to normalize the indicators of microcirculation after application of EMF (Table 1).

Table 1

Correlation links between the original values of the characteristic
and the effect of exposure to EMF (r)

	M	NT	MT	PSh
1st group	- 0.249	- 0.354	- 0.338	- 0.621
Group 2	- 0.551	- 0.789	- 0.615	- 0.494

In addition, it can be noted that in group 2, all marked connections are more pronounced. According to the indices of NT, MT and PS, the significance of the regulatory influence of EMF is quite high. Thus, in the first group, the significance of the regulatory effect of BRT was as follows: NT - p (ETF) = 0.004, MT - p (ETF) = 0.041, PS - p (ETF) = 0.001. In the second group NT - p (ETF) = 0.002, MT - p (ETF) = 0.003, PS - p (ETF) = 0.023. The data obtained indicate the influence of endogenous EPM on the ways of regulation of vascular tone and microhemodynamics.

conclusions

The study shows that the state of microcirculation directly depends on the primary pathology of the operated patient. The effect of exposure to endogenous low-intensity electromagnetic radiation correlates with the initial state of the vascular bed. A short-term, five-minute exposure to EMF with the specified characteristics does not significantly affect the speed indicators of microhemodynamics. Low intensity
an electromagnetic field of endogenous origin has a regulating effect on the state of microcirculation, normalizing the state of microvessels. The effects we observed are consistent with the literature data.

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