

Idiopathic Scoliosis, Growth Zones, Magnetic Therapy

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Abstract. Background The study has been performed to investigate the influence of pulsed magnetic field on the bone growth plates to get new grounds of magneto therapy in AIS treatment. Materials and methods. Were used methods of "strong" and "weak" pulsed magnetic fields influence. Results. Application of pulsed magnetic field causes an authentic inhibition of chondrocytes' active proliferation processes, decreases the index of labeled nuclei, indicating the suppression of DNA synthesis, takes place an increase in the unit weight of the more "mature" differentiated chondrocytes. The final result of these effects is the accelerated synostosis of bones' growth plates. Conclusion. Regardless of the reasons that cause growth infringements, the operating organ in the chain is the body's growth plate. Therefore, the appliance of magnetic fields in AIS treatment can be considered as a perspective one concerning growth plates' functional activity local management. To our point of view, the potential of magneto therapy methods in child's orthopedic treatment is significantly higher compared with modern practice.

Keywords. Magnetic field, growth plates, AIS treatment.

Introduction

It is well known that growth is a key factor in the AIS pathogenesis. Moreover, in our clinic, on the basis of carried out experimental trials, mathematical modeling and long-term clinical observations of patients with AIS were obtained convincing arguments showing that scoliosis is initiated by the growth conjugacy violation of the spinal cord and bone vertebra column [1]. This view allows us to consider AIS as a clinically significant compensatory response to the referred conjugacy. Thus, it becomes apparent that for effective treatment of AIS should be applied therapeutic effect, which would "slow down" vertebra column growth and/or have a stimulating effect on the spinal cord longitudinal growth. Treatment factors must meet the following requirements: safety, noninvasiveness, availability.

After analyzing the available medical techniques and research experience in biophysics at the present stage, we came to a conclusion that potentially feasible is the first task - growth inhibition of the spinal column.

As a "Tool" for the therapeutic effect were identified magnetic fields. This choice is explained by the following factors: 1 - multiple and independent studies demonstrated the possibility of magnetic fields impact (even very weak) on biological processes; 2 - the magnetic field can non-invasively affect the internal structures without any discomfort to the patient; 3 - was confirmed experimentally the ability of magnetic fields with certain parameters to accelerate or inhibit cells' proliferation [2,3,4,6].

As a "Target" for magnetic therapy with the aim to suppress vertebra column growth were selected areas of spinal growth plates, as it is through these anatomical structures is going an increase in linear dimensions of the skeleton bones. In the series of carried out trials was studied the impact on the spinal growth plates as of "strong" magnetic fields (up to 1.5 Tl) in the pulsed mode, so as of "weak" (the intensity of which is comparable to the natural field of the Earth) combined magnetic fields, which action is based on the effect of ion - parametric resonance.

The aim

To determine the curative possibility of magnetic field's impact on the growth bone plates in patients with AIS carried out on experimental animals.

1. Materials and Methods

As a source of "strong" magnetic field with the specified parameters was used the device for pulsed magnetic therapy "Amit-01" with the level of induction up to 1,5 Tl and pulse's duration - 110 ms (Russia).

For generating "weak" magnetic fields was used the original device capable to generate an alternating magnetic field with the set-up resonant frequency. In this work were used magnetic fields with the effect of ion - parametric resonance for potassium ions, which according to the biophysical studies [6] can lead to suppression of proliferation. The parameters of our "weak" combined field are as following: induction of a constant field $48,0 \pm 0,4$ mTl, the induction of the alternating field depended on the value of the constant component and was installed automatically.

1.1. Experimental animals

34 rabbits breed "Soviet Chinchilla" at the age of 1 - 3 months, 16 mice - C57BL / 6.

1.2. Methods of influence with "strong" pulsed magnetic field

The impact was implemented locally to the area of the knee joint of the experimental rabbit's right hind limb. For this purpose the inductor's generator "Amit-01" plane was applied tightly to the lateral surface of the rabbit's right knee joint with movement's restriction by special appliance. Each experimental animal was exposed to 15 procedures of pulsed magnetic fields. All procedures were performed in the morning

(8-00 - 10-00 hours). Treatment time - 10 minutes. In the group of control animals 15 times was imitated the procedure, the device was not activated.

1.3. Methods of influence with "weak" combined magnetic field

The overall impact of the given fields on the entire body was implemented. During the experiment the animals were kept inside a special appliance, where were created conditions for the ion - parametric resonance for the potassium ion. Exposure time in the magnetic field - 40 min., 15 procedures - daily. In the group of control animals 15 times was imitated the procedure in the same appliance.

As the **object of the study** were selected growth plates of the distal femur and proximal - tibia. To determine the qualitative and quantitative changes in bone growth plates of the knee joint were applied morphometric and autoradiographic methods.

1.4. Morphometric methods

The fragments of the investigated bones were specially prepared and embedded in paraffin according to the common scheme [5]. In experiment the paraffin blocks were oriented in a way to make able to obtain sections in the frontal plane. Slices with thickness of 20 mm were fulfilled on the microtome "Reichert". The got patterns were coloured with hematoxylin and eosin, colouring agent Romanowsky-Giemsa and according to the Mallory method. The thickness of the growth plate was evaluated with the help of ocular - micrometer at 20x lens, ocular 15x and expressed in micrometers (microns). Was held calculation of the average number of chondrocytes in growth plates zones of so-called "rouleaux". Along with that was determined the percentage ratio of the zone of differentiated ("mature") and proliferating ("young") chondrocytes.

1.5. Autoradiography

The activity of DNA synthesis was determined by means of autoradiography. As a mark was used 3H-thymidine. After dilution in saline solution 3H-thymidine was injected intravenously after the last magnetic field exposure. The staff was taken in one hour after injection of 3H-thymidine. To register the activation of radioactive label were applied liquid emulsions type "M" (SRIKFI, Moscow) on the deparaffined sections and exposed for one month. Further was used the developer D-19. On the coloured with hematoxylin and eosin autographs was calculated the index of labeled nuclei (the ratio of radio-labeled nuclei to total nuclei) with 20x -lens and 15x -ocular. On a standard rectangular area (ocular grid) of epiphyseal plate was calculated the total number of nuclei of chondrocytes and labeled nuclei among them. Was also calculated the index of labeled nuclei (ILN). Count's areas were evenly distributed along the length of growth plate at the distance of 350 microns.

2. Results

It was found out that a "strong" magnetic field (the level of induction of 1.5 Tl) in the pulsed mode can cause suppression of the functional activity of bone growth plates in

experimental animals, what was manifested in the inhibition of proliferation and reduced DNA synthesis, as observed in some animals even accelerated synostosis of growth plates. The factual data are given in the Table 1.

Table 1. Changes in some morphometric parameters of growth plates (GP) of the femur and tibia bones after the impact of pulsed magnetic field

	GP Femoral bone				GP Tibia bone			
	Height, μm		The share of differentiated chondrocytes, %		Height, μm		The share of differentiated chondrocytes, %	
	Experiment	Control	Experiment	Control	Experiment	Control	Experiment	Control
GP Morphological indices	253 \pm 28	333 \pm 25	31,4 \pm 1,2	34,3 \pm 3,1	316 \pm 23	354 \pm 10	40,2 \pm 2,7	32,4 \pm 2,1

According to the data in the table number 1, there was an authentic decrease in the total height of the knee joint growth plates. In the experimental animals compared with the control group of similar age was observed the decrease by 24% of the hips and 10.7% of the tibia ($p < 0.05$). In addition, there was unit weight authentic increase of differentiated chondrocytes zone by 19.4% of the tibia ($p < 0.05$), in the femur was indicated a slight tendency to decrease in this area - by 8.5% ($p > 0.05$). In other words, there are observed two simultaneous processes - reducing of growth plates' height and the increase in the proportion of differentiated chondrocytes.

It should be noted that in some growth plates preparations were observed areas of degenerative changes.



Figure 1. Growth plate of the femur (left) and under degenerative changes (right) after exposure to pulsed magnetic fields. Colouring by Mallory's method (5); ob.10x, oc.10x.

Additional data, confirming the morphometric parameters were obtained during the autoradiographic trial. It was found that the ILN of the experimental animals is significantly lower than in control group ($p < 0.05$): the decrease in the growth plates of the right femur by 32.5%, and in the tibia, on average - by 40.3%.

Factual results of autoradiographic studies of this subgroup of animals are shown in the Table 2.

Table 2. Effect of pulsed magnetic fields on DNA synthesis of chondrocytes growth plates.

	The index of labeled nuclei, (%)			
	Femoral bone		Tibial bone	
	Experiment	Control	Experiment	Control
Growth plate	2,7 \pm 0,2	4,0 \pm 0,5	3,7 \pm 1,1	6,2 \pm 1,7

Analysis of these data clearly indicates a significant decrease in proliferative activity, which in turn provides the basis for the conclusion: the influence of pulsed magnetic field inhibits the rabbits' growth plates and as a consequence leads to an accelerated synostosis.

The application of weak magnetic fields with the effect of ion parametric resonance also showed that the fields with these characteristics can influence the functional activity of bone growth plates' zones of experimental animals. Moreover, in contrast to the "strong" magnetic fields, we received a "softer" effect.

3. Conclusion

Thus, it may be noted that the application of pulsed magnetic field causes an authentic inhibition of chondrocytes' active proliferation processes, decreases the index of labeled nuclei, indicating the suppression of DNA synthesis, takes place the increase in the unit weight of the more "mature" differentiated chondrocytes. The final result of these effects is the accelerated synostosis of bones' growth plates.

The developed technology of the magnetic field with specified characteristics application makes it possible to reduce the functional activity of bone growth plates, hence and intensity of the longitudinal growth of bone vertebra column and, therefore, can be considered as pathogenetic treatment of AIS.

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