HYPERTHERMIA WITH MAGNETIC PARTICLES

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ГИПЕРТЕРМИЯ С МАГНИТНЫМИ ЧАСТИЦАМИ

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Аннотация. *В данной работе рассмотрено понятие гипертермии с использованием магнитных наночастиц. В настоящее время в ЦНИЛ СибГМУ (Центральная научно-исследовательская лаборатория) проводятся исследования нацеленных пептидами магнитных наночастиц для диагностики и терапии опухолей. Автором настоящей работы освоены методы работы с культурами клеток млекопитающих с целью последующего исследования гипертермии с нацеленными пептидом магнитных наночастиц in vitro.*

Introduction. Currently, an actual and priority direction is the use of nanomaterials in medicine and pharmacology. Nanotechnology makes it possible to create new directions for research. One of the promising directions is the phenomenon of local hyperthermia using magnetic nanoparticles.

Magnetic nanoparticles. The active interest in nanomaterials is explained by the fact that some of the fundamental properties of matter change at the nanoscale. Because of their size (from 4 to 100 nm) and the mass, nanoparticles occupy an intermediate state between individual molecules and living cells, so they can approach a bio-object and interact with it.

In case of nanoparticles obtained on the basis of magnetic materials, due to magnetic properties in nano-state change, the nanoparticles acquire ferro- and superparamagnetic properties. Today, a large number of magnetic nanoparticles based on metals have been synthesized. The magnetic properties of particles based on metal oxides are weaker than those of nanoparticles obtained from metals, but they are more resistant to oxidation. At present, iron oxide nanoparticles are most widely used because of their low toxicity and stable magnetic characteristics [1], [2].

Usually for medical use, particles are coated with a special coating performing several functions at once. It stabilizes the particles, protects them from oxidation, acid and alkali corrosion. Due to the coating, it is possible to modify the surface of nanoparticles by various functional groups that will allow the covalent bonding of nanoparticles and biomolecules or drugs. An important function of coating nanoparticles is to increase their biocompatibility [3].

The most actual area of research of nanoparticles in biomedicine is the development of new approaches to the therapy of oncological diseases, in particular, due to hyperthermia.

At present, there is an experience in the successful use of magnetic nanoparticles induced hyperthermia in combination with chemo- and radiotherapy for the integrated treatment of glioma in two clinics in Berlin [4].

Hyperthermia. The term "hyperthermia" means overheating of the body or the accumulation of excess heat with an increase in body temperature. The increase can be caused by both external and internal factors.

There are 3 types of therapeutic hyperthermia:

- Local hyperthermia - heating a certain area of the body, not limited anatomically.
- Regional hyperthermia - heating of a certain, anatomically limited region
- General hyperthermia, or hyperthermia of the whole body.

Most attention is paid to local hyperthermia, despite the fact that most of them are still at the stage of development and clinical trials. It deals with the fact that the use of local hyperthermia does not exclude the risk of overheating the whole organism. When the human body heats up to 42 °C, a heat stroke develops and causes serious negative effect on organism. Further temperature increasing provokes irreversible disturbances in the structure and function of proteins in the body, which are incompatible with life.

The simplest version of local hyperthermia is heating with hot water or using a metal needle that is injected into the affected area; another variant is concentration of the focused microwave radiation on this body area.

An advantageous variant of the local hyperthermia is magnetic hyperthermia with magnetic nanoparticles. The energy of altering magnetic field turns into internal energy of the particles leading to their heating. So the introduced magnetic material heats adjacent tissue. However, controlling the distribution of magnetic particles between healthy and diseased tissues is rather complicated, that can lead to overheating of healthy areas. One solution is to vectorize nanoparticles for targeted delivery only to the affected cells (Fig 1) [5].

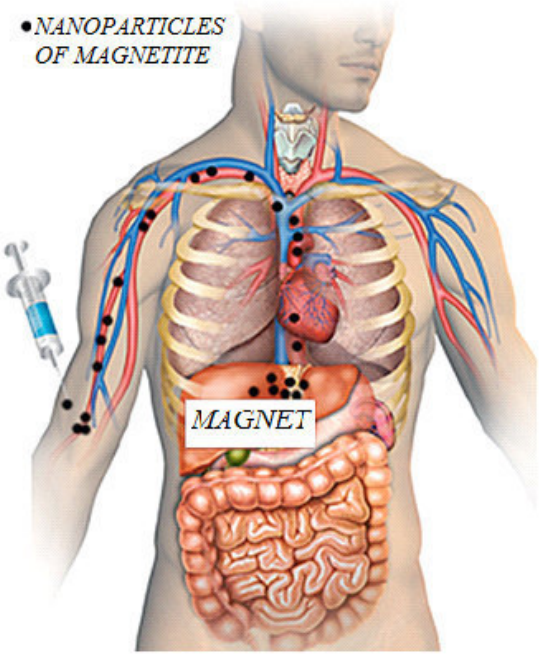

Fig. 1 scheme of targeted drug delivery

Magnetic hyperthermia has been used in fight against malignant neoplasms for more than 20 years due to the fact that some types of tumor cells in comparison with intact cells are more sensitive to elevated temperature. Nanoparticles are directed to the tumor region and then heated to 42–43 ° C in an alternating magnetic field as a result of which the tumor cells die and the healthy cells remain intact. Hyperthermia is successfully used in parallel with chemotherapy or radiotherapy, as a result the effectiveness of therapy significantly rises.

Information on whether the nanoparticles have reached their target can be provided by magnetic resonance imaging (MRI). Magnetite-based nanoparticles have MRI contrast properties, and therefore they are used not only for therapy, but also for diagnosis of tumors at the earliest stage.

However, magnetic hyperthermia is not used universally, which is associated with some problems, which primarily include the risk of vascular embolism due to the accumulation of particles within the blood vessels in the targeting area. Also the successful implementation of local hyperthermia often requires the imposition of very strong magnetic fields, which is not always possible.

This determines the conduction of scientific research aimed at optimizing the behavior of targeted magnetic nanoparticles in the body and their physical and chemical characteristics, to achieve effective accumulation in the tumor and its following destruction.

The author of this work has mastered the methods of working with cell cultures of mammals. At the next step of the work, it is planned to use magnetic nanoparticles of iron oxide with the targeted peptide for use in hyperthermia, and also to study their effectiveness.

Conclusion. Despite the fact that the phenomenon of local hyperthermia with the use of magnetic nanoparticles has its shortcomings and is not used everywhere, today it is a priority direction, as it provides an increase in the effectiveness of therapy and thereby, improves the quality of life of patients.

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