Nanotechnology can help treat cancer

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Good health is one of the most important things for human beings. Cancer is a disease that has been threatening the health of mankind for many years and has been a major disease in modern society. It is estimated that one out of two people in Japan will be diagnosed with cancer at least once in their lifetime, and cancer has been the leading cause of death in Japan since 1981. It is reported that nearly one million people are newly diagnosed with cancer each year, and nearly two hundred thousand people die from cancer every year. It is also assumed that the number of cancer cases will continue to increase with the aging society.

To tackle this challenge, methods of treating cancer have been studied extensively. Currently, the main cancer treatment methods include surgery, radiation therapy, and chemotherapy. Among these, developing methods that have fewer side effects on patients is especially important. However, existing methods have difficulty in achieving this. For example, chemotherapy has the problem of destroying normal cells in addition to cancer cells when medicines are administered.

Under such circumstances, there are movements to apply nanotechnology to cancer treatment. Nanotechnology is a general term for technology that controls materials at the size of atoms and molecules. It has been developing rapidly in recent years and has already become an indispensable technology in our lives. For example, nanotechnology is highly utilized in semiconductor integrated circuits contained in electronic devices.

One of the attempts to apply nanotechnology to cancer treatment is to use magnetic nanoparticles. Magnetic nanoparticles, typically made of magnetite (Fe_3O_4) and

maghemite (Fe_2O_3) are particles with a diameter of several tens of nanometers. One of the cancer treatment methods using magnetic nanoparticles is cancer thermotherapy. In cancer thermotherapy, magnetic nanoparticles are sent to the tumor site and heated to kill the tumor. This method is based on the fact that cancer tissue is generally destructed by heat of 42.5 degrees Celsius or higher. A similar method that doesn't use the nanoparticle already exists. In this method, a pair of electrodes is set on the front and back of the body so that the affected area is sandwiched between them, and a high-frequency current is applied to the inside of the body to raise the temperature of the affected area. However, this method is not very effective because the body surface and other parts of the body may be heated to a higher temperature and damaged before the tumor temperature reaches 42.5 degrees Celsius. On the other hand, by using magnetic particles, it is possible to heat only the magnetic particles near the tumor by applying an alternating magnetic field and changing the direction of the magnet periodically like creating a local kitchen at the location of the tumor and heating the tumor as if it were cooked. The advantage of this treatment is that it does not have the side effects like anticancer drugs because it is a physical treatment using heat.

This technique was first proposed by Gordon et al. in 1979 [1]. In their research, they used rats as experimental subjects and found that magnetic nanoparticles could be delivered to mammary tumors and then heated to destroy the tumor cells. Since then, the development of nanomagnetic particles and their application to various targets have been studied. To date, various preclinical studies have been conducted [2], including melanoma (skin cancer) and breast cancer in mice, subcutaneous implantation models of human prostate cancer in thymus-free mice, spontaneous melanoma in transgenic mice, and a rabbit tongue cancer model, and so on.

As described above, cancer thermotherapy using magnetic nanoparticles is useful and has the potential to be a new cancer therapy. However, most of the studies to date have remained in the laboratory and few have been applied in the clinic. While there needs to be further development in magnetic nanoparticles, there should also be more research on the effects of magnetic nanoparticles on the human body, including their toxicity and long-term effectiveness. In addition, a large amount of clinical research is also needed to utilize them in the real world.

Despite more challenges, the future of medical applications of magnetic particles is bright. In addition to the heat therapy described in this essay, there are many other applications of nanomagnetic particles. One application is to take magnetic particles with drugs attached to the body, transport them to the tumor site using an external magnetic field, and directly administer the drugs. Other applications include the use of nanomagnetic particles as MRI (Magnetic Resonance Imaging) by utilizing the fact that they respond to magnetic fields. [2] Further development of nanotechnology, medicine, and biology may lead to the realization of a new and revolutionary method of cancer treatment using magnetic nanoparticles.

[1] R. Gordon, *et al*., A Biophysical approach to cancer treatment via intracellular temperature and biophysical alterations, Medical hypotheses **5**, 83-102 (1979).

[2] A. Ito, Medical technology using functional magnetic nanoparticle, Seibutsu-kogaku **97,** 122-129 (2019).